THE OLD RED SANDSTONE OF BROWN CLEE HILL AND THE ADJACENT AREA

I. STRATIGRAPHY

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II. PALAEONTOLOGY

BY

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THE OLD RED SANDSTONE OF BROWN CLEE HILL AND THE ADJACENT AREA

This paper is dedicated to the late William Wickham King

PART I. STRATIGRAPHY

By HAROLD WILLIAM BALL & DAVID LAWRENCE DINELEY

CONTENTS

SYNOPSIS

The stratigraphical and faunal succession of the Old Red Sandstone, which forms the greater part of the area about Brown Clee Hill, Shropshire, is described. The Lower Old Red Sandstone forms a conformable sequence which is subdivided into the Downton, Ditton and Clee Series. The base of the Downton Series (Downtonian) is demarcated by the Ludlow Bone Bed, and the Series shows a gradation from predominantly buff and grey sediments (Grey Downton Formation) to purple and red beds (Red Downton Formation) which include local developments of sandstones near the top. The upper part of the Downton Series falls within the zone of *Traquairaspis symondsi*. The Ditton Series (Dittonian) commences with the main "*Psammosteus*" Limestone; it is subdivided into a lower group composed largely of red and purple marls with sandstones and cornstones, broadly equating with the zones of *Pteraspis* (*Simopteraspis*) *leathensis* and *Pteraspis* (*Belgicaspis*) *crouchi*, and an upper group in which the marls are largely replaced by silts, with an increase in the proportion of sandstones and cornstones, and a change to predominantly red-brown, brown-buff and grey-green coloration. The upper group corresponds to the zone of *Pteraspis* (*Cymripteraspis*) *leachi*. The Clee Series (Breconian) consists largely of unfossiliferous grey, buff, brown and purple sandstones and silts, the base of the Series being formed by the lower Abdon Limestone. This sequence is unconformably overlain by the Upper Old Red Sandstone comprising the Farlow Sandstone Series (Farlovian), which is subdivided into a lower (Yellow) and an upper (Grey) Formation. A further unconformity occurs between the Farlow Sandstone Series and the basal conglomerate of the Carboniferous. An account is also given of the structure and geological history of the area.

The fauna is discussed and five new genera, one new subgenus and fifteen new species are described and figured.

I. INTRODUCTION

(a) *Geographical Setting*

DOMINATING the area to be described is Brown Clee Hill which has an "hour-glass" shape and is elongated in a N.–S. direction. The hill is largely composed of beds of Breconian age folded into a syncline, the axis of which extends NNE.–SSW. thus diverging slightly from the hill's topographical axis. A thin series of Coal Measures unconformably overlies the Breconian and is in turn capped by the remnants of dolerite sheets[1] at Abdon Burf and Clee Burf, the northern and southern eminences respectively, the former at 1,790 ft. O. D. being the highest point in the Midlands.

Brown Clee Hill is connected by relatively high saddles with Titterstone Clee Hill to the south and Weston Hill to the south-west, whilst west and north extends the high level platform of Ditton Priors. This platform is formed by the Ditton Series and bounded by the prominent escarpment of the sandstones associated with the "*Psammosteus*" Limestones. Below the escarpment to the west lies Corvedale, incised into the less resistant strata of the Downton Series and drained to the south-west by the River Corve; to the south-east a smaller complementary valley has been cut by the Ledwyche Brook.

[1] A contact between the top of the dolerite and the base of the overlying carbonaceous shales, exposed in the old quarry at Clee Burf, showed the shales to be baked to a depth of 2 in., supporting Marshall's (1942) interpretation of the intrusive form of the Clee dolerites as opposed to Pocock's (1931) extrusion hypothesis.

To the east, between Brown Clee and the Coal Measures of the Wyre Forest, a broad outcrop of Ditton Series gives rise to more undulating topography, the cornstone and sandstone horizons characteristic of this Series forming numerous minor ridges and escarpments. The southern margin of the area is demarcated by the scarp slope of the Cornbrook Sandstone which forms the north flank of Titterstone Clee Hill, and by the ridge of the Farlow Sandstone Series and the overlying Carboniferous Limestone extending eastwards from Farlow. The drainage of the area to the east of Brown Clee Hill centres upon the River Rea which flows to the south-south-east, breaching the Farlow ridge at Prescott and ultimately joining the River Teme, as does its western neighbour the Corve.

(b) *Historical Review*

Despite the relatively numerous references to the geology of the area, most of our knowledge is based upon the researches of two authors. The first of these was Murchison, who gave the fullest account in his epic *Silurian System* (1839), subsequent versions of which appeared in the several editions of his *Siluria*. It was almost a century later that the other major contributions appeared by W. Wickham King (1925, 1934) who established the first detailed succession based on lithological characteristics.

More recently, White (1950*a* ; White & Toombs, 1948) has suggested a modification of this succession to conform with the results yielded by his valuable researches into the ostracoderm faunas of the Old Red Sandstone of the Welsh Borderland and South Wales. Other contributions to the vertebrate palaeontology of the area have been those of Egerton (1862), Stensiö (1932, 1948), A. S. Woodward (1934) and Wills (1935).

The area was first systematically mapped by Robert and Romley Wright during the early part of the last century, as noted by Murchison (1839 : 112) who also appended a map and sections to the *Silurian System*. These were followed by the Geological Survey during the period 1850–55, the results being published in the Old Series 1-in. scale maps, sheets 55 NW. and NE., and 61 SW. and SE. The eastern extremity of the area is included on the New Series 1-in. scale map, sheet 167, and some interesting conclusions regarding the subdivision of the Lower Old Red Sandstone are included in the Memoir on the sheet (Whitehead & Pocock, 1947).

The present account, based on mapping on a scale of 6 in. to a mile and in some instances 25 in. to a mile, originated as two independent pieces of research, one author working upwards from the Downtonian, the other working downward from the Farlovian, both meeting in the common ground of the Dittonian. Thus one of us (D. L. D.) is entirely responsible for observations on the succession ranging upwards from the base of the Downton Series to the " *Psammosteus* " Limestones, the other (H. W. B.) for the succession upwards from the base of the Clee Series. The description of the Ditton Series above the " *Psammosteus* " Limestones is a combined account. A brief summary of these researches has been published in an excursion guide to the area (Ball & Dineley, 1952).

(c) *Stratigraphical Succession*

Lower Carboniferous		
Basal Conglomerate		6–40 ft.
unconformity		
Upper Old Red Sandstone		
Farlow Sandstone Series		230–510 ft.
Grey Farlow Sandstone Formation	40–300 ft.	
Yellow Farlow Sandstone Formation	190–210 ft.	
unconformity		
Lower Old Red Sandstone		
Clee Series		900 ft.
Ditton Series		1,200–1,450 ft.
Upper group of marls, silts, sandstones and cornstones	400–550 ft.	
Lower group of marls, sandstones and cornstones	800–900 ft.	
Main " *Psammosteus* " Limestone	0–16 ft.	
Downton Series		1,150–1,250 ft.
Red Downton Formation	1,070–1,100 ft.	
Grey Downton Formation (with Ludlow Bone Bed at base)	80–150 ft.	

II. LOWER OLD RED SANDSTONE

STRATIGRAPHY

The delimitation of the subdivisions of the Lower Old Red Sandstone sequence in the Anglo-Welsh area has long been a source of controversy, and also its junction with the Silurian (see White, 1950*a*). As originally defined by Lapworth (1879–80), the Downtonian comprised the Upper Ludlow Shales, the Ludlow Bone Bed and the Downton Castle Sandstone. Subsequently, the term was used by several authors to embrace differing groups of strata. However, the most generally accepted classification of the Old Red Sandstone has been that of W. Wickham King who divided it into lithological stages. Utilizing Lapworth's term " Downtonian " as defined by Peach & Horne (1899 : 568), King applied it to a succession of purple marls, shales and sandstones overlying the Temeside Shales (1917 : 97, 98). He later (1925) extended it to embrace a great thickness of predominantly marly beds, and referred to it in his table of succession (p. 383) as the " Downtonian or *Anaspida* marls ", though it is not clear from his table whether he regards the Ludlow Bone Bed as forming the base of the " so-called Old Red Sandstones ". Subsequently in the same paper a further name, " Downtonian Series ", was introduced for the same beds. Similarly, the succeeding strata were referred to in the table of succession as the " Dittonian or *Pteraspis* Cornstones " and later as the " Dittonian Series ", the term " Dittonian " having been introduced by King in two earlier papers (1921*a*, *b*). The junction between the Downtonian and Dittonian was designated as the base of the " *Cephalaspis* Sandstone—cornstone", occurring up to 300 ft. above the " *Psammosteus* " Limestones. Above the Dittonian, " Brownstones " were tentatively recorded, with the " Farlow Sandstones " unconformably overlying the Dittonian and the Brownstones.

King (1934) retained the terms " Downtonian " and " Dittonian ", discarding the alternative names, although in his table of succession (p. 527) he referred to the " Downtonian Marls ". Both the Downtonian and Dittonian were regarded as the upper part of the Silurian, the Ludlow Bone Bed being included with the Upper Ludlow. A more recent summary of the Old Red Sandstone succession based largely on King appears in Wills (1948), which notes the " Brownstones " as unconformably overlying the Dittonian, though this is considerably emended in a later edition (Wills, 1950).

The practice of the Geological Survey regarding the subdivision of the Old Red Sandstone has been varied and is summarized by White (1950*a* : fig. 2). Most recently, and with special reference to this area, Whitehead & Pocock (1947) placed the Downtonian-Dittonian boundary at the base of the " *Psammosteus* " Limestones, retaining the Downtonian with the Silurian. The beds below the " *Psammosteus* " Limestones were given the stratigraphical name " Downton Series ", and those above and including the limestones the name " Ditton Series ".

From his researches into the fish faunas of the Lower Old Red Sandstones of the Anglo-Welsh area, White (1950*a* ; White & Toombs, 1948) arrived at similar conclusions, though differing from Whitehead & Pocock on one very important point, namely, the inclusion of the Downton Series with the Old Red Sandstone. He regarded the Dittonian as being marked by the appearance of *Pteraspis*, approximately at the level of the " *Psammosteus* " Limestones.

In Corvedale, one of us (D. L. D.) has found that there is one main limestone horizon which, though showing some lateral variation, can be traced throughout the area. Therefore, with regard to drawing a well-defined marker horizon, the acceptance of the " *Psammosteus* " Limestones as the Downtonian-Dittonian boundary, as proposed by Whitehead & Pocock (1947), is an obvious solution. However, since *Pteraspis* (*Simopteraspis*) *leathensis* White has now been found to occur below the limestones, the boundary does not coincide with that of White's faunal zonation. Nevertheless, it has been amply demonstrated in many fields of palaeontology that faunal assemblages and maxima are more reliable indices than the appearance and disappearance of individual species. Moreover, for this area, the correlation between the faunal and stratigraphical horizons is suggested as being sufficiently close for them to be regarded as broadly contemporaneous.

In the present work the stratigraphical names (i.e. time-rock units) " Downton Series " and " Ditton Series " are retained, whilst the " Downtonian " and " Dittonian " are regarded as denoting the equivalent epochs (time units) within the Lower Old Red Sandstone. The highest part of the Lower Old Red Sandstone sequence occurring in this area is formed by the Clee Series, representing the Breconian epoch.

(a) *Downton Series*

The Downton Series comprises a sequence of 1,150 to 1,250 ft. of predominantly red and purple marls, with thin lenticular sandstones and pellet beds distributed irregularly throughout its middle and upper parts. The Ludlow Bone Bed is here accepted as the base of the Series, whilst the succeeding Ditton Series is regarded as commencing with the main " *Psammosteus* " Limestone (see below). The Downton Series is subdivided into two groups, the lower Grey Downton Formation, corresponding to the Temeside Group of Robertson (1927), and the succeeding Red Downton Formation, equivalent to the " Red Downtonian beds " of Whitehead & Pocock (1947 : 4).

(i) *Grey Downton Formation*

This formation consists of olive, grey and buff flags and shales with occasional purple marls, and is transitional between the shales of the Upper Ludlovian and the marls of the Red Downton Formation. In the Ludlow area the subdivision of this facies into Ludlow Bone Bed, Downton Castle Sandstones and Temeside Beds can be clearly demonstrated (Elles & Slater, 1906), but it is not possible to maintain this subdivision with certainty in Corvedale where the exposures are few and poor. The Ludlow Bone Bed in Corvedale has been mapped by Robertson (1927). No new exposures have been found, whilst some of those examined by Robertson no longer exist and there is no certainty that they all form part of a constant, single stratum ; indeed, Elles & Slater and Robertson recorded more than one bone bed horizon between Ludlow and Much Wenlock. It has not been possible to distinguish the Downton Bone Bed.

Whilst there is no sharp division of the Grey Downton Formation into the members recognized at Ludlow or Much Wenlock, the same general sequence occurs. There is a progressive transition from grey calcareous to red facies :

Lithologies	Ludlow	Corvedale	Much Wenlock
Grey, olive, purple and chocolate mottled shales and mudstones	120 ft.	Generally less than 90 ft.	50 ft.
Thin-bedded pale sandstones. Massive yellow sandstones. Downton Bone Bed (local). Olive sandy shales. Ludlow Bone Bed	30–50 ft.	30–40 ft.	30 ft.

Despite the lack of exposures, it is apparent that thick sandstones are few and impersistent and that the facies change occurs within a maximum thickness of 170 ft. in the south, the thickness decreasing northwards, at least as far as Shipton. From the area around Norton to Diddlebury, the formation decreases from at least 150 ft. to 90 ft. in thickness. Near Hungerford and Broadstone, an estimated 100 ft. of olive shales and chocolate-purple mudstones lie below dark red marls, some of the beds being extremely micaceous. Nothing can be added to previous accounts of the palaeontology.

(ii) *Red Downton Formation*

The red marls and occasional impersistent sandstones constituting this formation outcrop in the low land of Corvedale, the Ledwyche Valley and to the north of Monkhopton and Morville. There is a continuous upward transition and the fossils are rare and confined to highly localized concentrations. In view of this, the limits of the formation are based largely upon lithology. The junction of the Red Downton Formation with the Grey is drawn where the first thick red marls appear and is thus somewhat arbitrarily fixed between exposures in western Corvedale. As White (1950*a* : 54) has suggested, the lowest parts of the red facies may well be coeval in places with part of the grey elsewhere. The main "*Psammosteus*" Limestone (see below) appears to form a mappable horizon about 1,100 ft. above the base of the Red Downton Formation.

The marls greatly resemble those of the Trias and are usually extremely fine-grained, red, chocolate or bluish purple, with frequent green-stained, ramifying bands, spots and joint-planes. Petrographically they are identical with those of the Red Marl Group in the Cardiff district described by Heard & Davies (1924 : 502). Usually there is little trace of bedding or lamination, but the cuboidal jointing on weathered surfaces, characteristic of Triassic marls, commonly occurs. Some horizons, however, include finely laminated, micaceous siltstones. Also associated with the marls are thin bands of small, closely packed, calcareous concretions ("race"), which sometimes take the form of thin, irregular, vertical rods, reaching 4 in. or so in height and ½ in. in diameter.

Thin, lenticular sandstones and pellet beds are irregularly distributed throughout the marl sequence, especially near the base and locally in the middle and upper parts of the formation. In particular, two sandstone developments, the "Holdgate coarse sandstone" and the "*Ischnacanthus* Sandstone", were defined by King (1925 : 384; 1934 : 527) as "stages" of his Downtonian, occurring 815 ft. and about 1,230 ft. respectively above the Ludlow Bone Bed. Subdivision based upon lithology is, however, impracticable in these variable sediments and the scarcity of fossils makes palaeontological zonation equally difficult. Nevertheless, the lowest sandstones of the formation may be equivalent to the "*Thyestes* (*Auchenaspis*) Sandstone" of Ledbury, whilst those at the top are indistinguishable from the Dittonian sandstones. The sandstones are lenticular and vary considerably in colour and grade. They consist largely of subangular or angular quartz grains, with varying amounts of mica, feldspar, accessory heavy minerals and clay minerals with ferruginous or calcareous cements, the latter often showing lustre-mottling. Pellets and flakes of marl are frequently included, sometimes in such profusion that the sandstone grades into a pellet rock. With an increase in calcium carbonate the pellet rocks may in turn grade into a cornstone. Near the base of the "*Psammosteus*" Limestones escarpment several very coarse grits are known, but no pebble beds of the type described by Heard & Davies (1924 : 495) have been found.

Opinions as to what constitutes a "cornstone" vary widely (see Allen, 1960), but as stated by Murchison (1839 : 55, footnote 2), "In the country . . . of the Old Red Sandstone, the name of 'Cornstone' is restricted to the coarse, sandy, conglomerate-like masses, and is never applied to the large concretions of purer limestone"; and again a little further on (p. 180), " . . . while at intermediate places [the cornstones] consist of marl, limestone, and sandstone, irregularly concreted, and have the aspect of a conglomerate. In the last-mentioned form alone, they constitute the cornstones of the inhabitants . . . ". Thus, throughout this paper the term will be employed in this context.

Cornstones are most conspicuous in the uppermost Red Downton Formation and the Ditton Series. Generally they are from 1 to 4 ft. thick, though reaching as much as 14 ft. in the Ditton Series. They vary widely in lithology, ranging from relatively pure to gritty and marly limestones, and may be red, purple, buff, grey-green, green or variegated in colour, according to the form and amount of the iron salts present. They are largely composed of fragments of muddy limestone or calcareous marl, commonly rounded or sub-rounded, though occasionally sub-angular, ranging in size from a few millimetres up to several centimetres. Some cornstones consist mainly

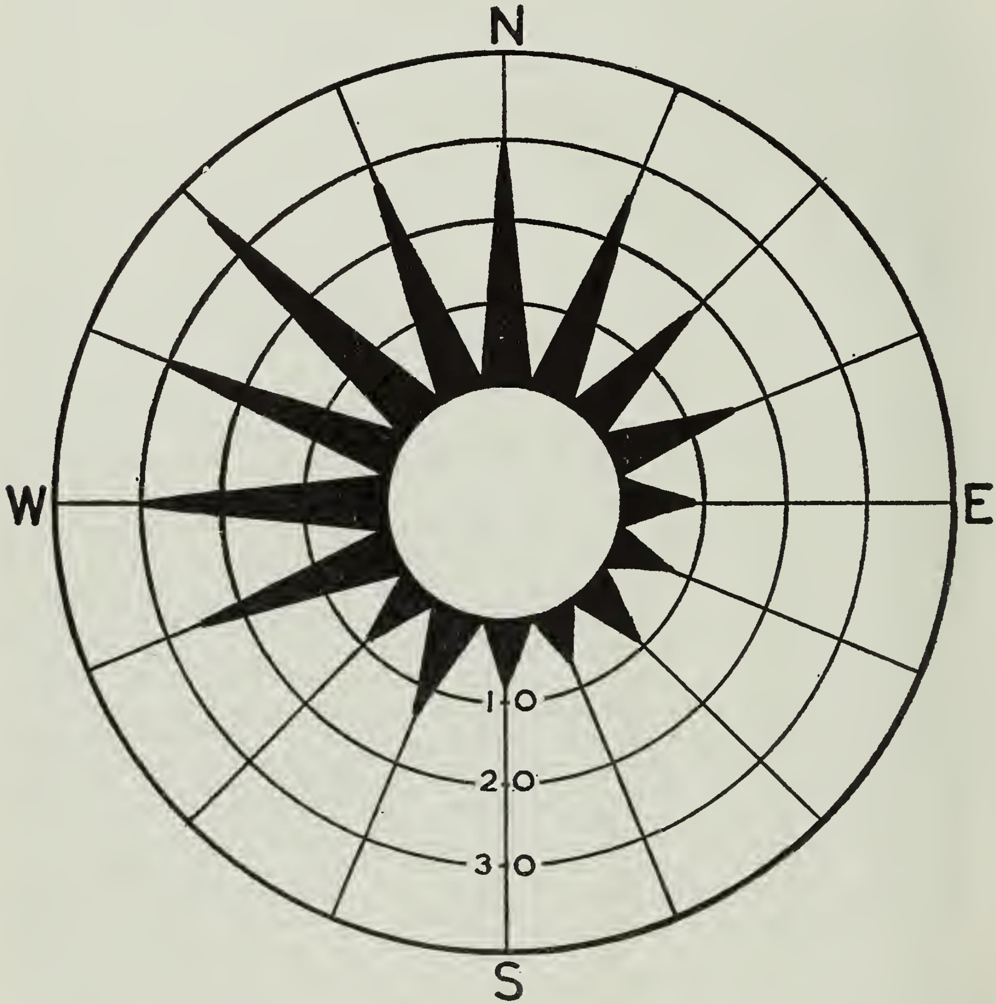


FIG. 1. Current directions as indicated by dips recorded from foreset beds in sandstone and conglomeratic cornstone units within the upper part of the Downton Series and the lowest 400 ft. of the Ditton Series, measured on the northern and western slopes of Brown Clee Hill.

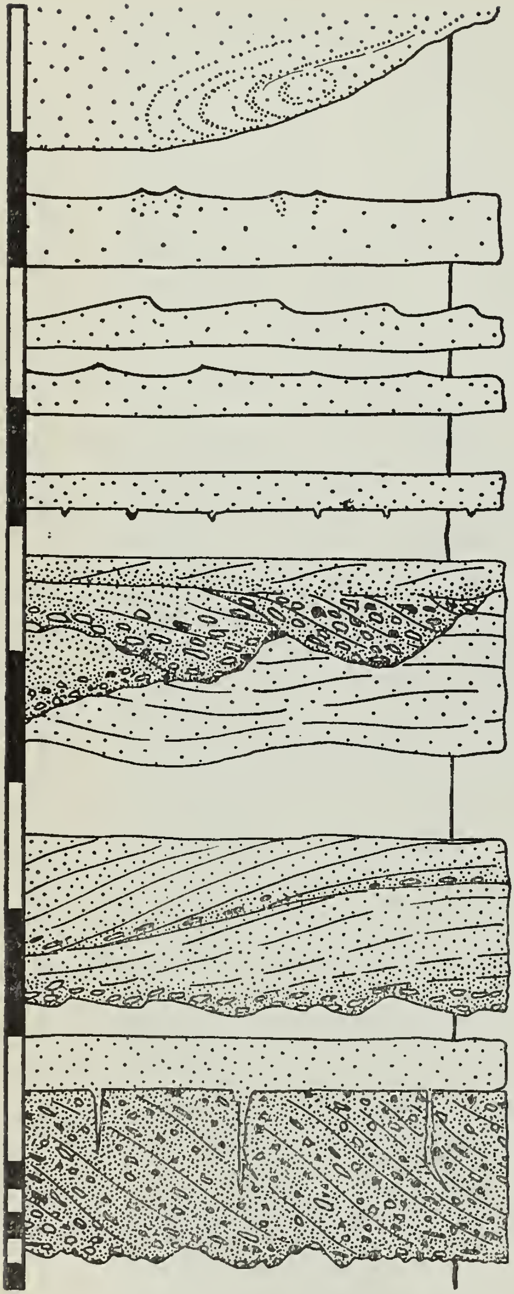
of one type of pellet or of water-sorted " race ", whilst others also incorporate pebbles of vein quartz, cherts, jasper, and pellets of vegetable carbon. The matrices consist of crystalline and muddy calcite, marl and sand in varying proportions and, when weathered, the beds may assume a nodular or rubbly appearance. Fragmentary fish remains frequently occur, sometimes in considerable local concentrations. The calcareous bodies ascribed to algae by Heard & Davies (1924 : 505) in the Cardiff district, have not been found in the present area. Many of these beds rest upon highly irregular erosion surfaces, sculptured into the marls to a depth of several inches. Cross-bedding, in which the foreset beds are generally less than 1 ft. thick, is common and some of the thicker cornstones show successively overlapping, short, irregular, cross-bedded lenticles between 1 and 4 ft. thick. A few strikingly cross-bedded cornstones appear as " wash-outs ", cutting locally through the underlying beds to a depth of 3 to 4 ft. From the measurement of some 300 separate foreset bed dips within the uppermost Downtonian and the Dittonian strata, it would seem that the dominant direction of transport was from the north-west (Text-fig. 1), though in any one section the directions may be reversed several times.

Oscillation ripple-marks are common in many sandstones, the crest intervals being usually between 3 and 5 in., though smaller ones are known and shallow marks with crest intervals of 9 in. or more occur upon the upper surface of some cornstones. Current ripple-marks with crest intervals of about $2\frac{1}{2}$ in. have also been found. Small desiccation cracks are present below a number of sandstones, whilst in the Lye Brook and on Titterstone Clee Hill very large ones occur. Vertical sandstone-filled fissures, some 2 ft. deep and $\frac{1}{2}$ in. wide, similar to those noted by Dixon (1921 : 29) in Pembrokeshire, penetrate the upper parts of cornstones at Aston Eyre and near The Alders (Text-fig. 2).

In the Fishmore Brick Pit, Ludlow, in beds which are probably low in the Red Downton Formation, several cross-bedded cornstones are exposed, each about 18 in. thick and 15 ft. long and consisting of poorly sorted, rounded marl pellets and " race ". They rest upon sharp, irregular marl surfaces and appear to represent gravel-filled runnels cut into the marl shortly after its deposition. Desiccation cracks and rain-pit markings occur in a sandstone band, and near the top of the brick-pit section a conspicuous sandstone wedges out sharply, showing near its termination small circular contortions of the bedding, possibly resulting from the slumping of the sediment in a channel incised in the marl (Text-fig. 2).

Near the base of the formation in western Corvedale, scattered, thin, lenticular, red and purple sandstones may represent the " Ledbury Beds " of Worcestershire, but have not yielded any diagnostic fossils. King appears to have established the presence of beds yielding *Thyestes* (*Auchenaspis*) *egertoni* (Lankester) to the north of Morville (Whitehead & Pocock, 1947 : 22). Six feet of closely alternating purple marls and fine ferruginous sandstones, temporarily exposed at Little Thonglands, near Holdgate, greatly resembled the " Ledbury Beds " of Ledbury (Piper, 1898), and pale red and green micaceous sandstones 400 yds. south-east of Brockton have yielded acanthodian spines.

King's stage I. 4, " Holdgate Sandstones ", was stated by him (1925 : 384 ; 1934 : 527) to occur at 815 to 830 ft. above the Ludlow Bone Bed. Subsequently, the term " Holdgate Sandstones Group " was retained for the sandstones near the middle of the Red Downton Formation (Ball & Dineley, 1952). However, there is little to distinguish these sandstones from others within the formation and it is perhaps best to use the term in its purely local connotation, i.e. only for the sandstones in the



Structures in sandstones and conglomeratic corn stones	Localities where structures were noted (List not exhaustive)
1. Lenticular units, slumping of sand down sides of small channels	Ludlow 513754, Stoke St. Milborough 574811.
2. " Spring-pits " . .	Tugford 565872.
3. Ripple-markings, asymmetric . . .	Bouldon 549841, 548840, Hayton 525815, Monkhopton 631926.
4. Ripple-markings, symmetric	Chetton 665901, Monkhopton 633922, Neenton 651871, Silvington 607798, Stanton Lacy 509802, 524778.
5. Desiccation-cracks	Bouldon 541840, Ludlow 513754, Morville 672928, Tugford 565869.
6. " Wash-outs ", scoured and filled channels in sandstone-cornstone units	Bouldon 552854, Hopton Cangeford 530805, Monkhopton 633943, Tugford 555863, Upton Cressett 648932.
7. " Rolling " or " wavy " bedding in sandstones ; undersurface may show tendency towards " flow-casting "	Bouldon 549850, Ditton Priors 606906, Monkhopton 634928, Neenton 653895, Stoke St. Milborough 512816, Upton Cressett 661922.
8. Cross-bedding, foreset beds at Low angles to surface of unit : units with little or no discordance between them	Ditton Priors 586887, Hopton Cangeford 549799, Monkhopton 625926, Silvington 623801, Stanton Lacy 509802.
9. Undersurface, possibly of relief, with non-linear features	Ditton Priors 612904, Middleton Priors 622907, Morville 672929, Stanton Lacy 519778, Tugford 555862.
10. Sandstone with " sandstone dykes " penetrating bed below	Aston Eyre 643932, Stoke St. Milborough 562802.
11. Cross-bedding, foreset beds at high angles to surface of unit. Units may be very irregular in thickness, foreset dips differ in successive units, base marked by erosion surface with sharp relief ; flutings and scour-marks may show preferred orientation	Bouldon 546848, Ditton Priors 610905, Holdgate 574889, Hopton Cangeford 530805, Monkhopton 631927, Morville 671928, Stanton Lacy 510801, Tugford 568877.

Fig. 2. Sedimentary features found in the Downtonian and Dittonian sandstones and conglomeratic cornstones of the Clee Hills area. Argillaceous beds left unstippled, vertical scale in feet.

vicinity of Holdgate village, where the principal sandstone horizon is about 650 ft. above the Ludlow Bone Bed. Sandstone lenses are recorded at many localities throughout central and northern Corvedale and in the country near Acton Round, at a few localities in southern Corvedale, and in the Ledwyche Valley. They are variable in grade and colour and many are very similar to the sandstone from " I. 5 " at Eastham brickworks, near Tenbury, Worcestershire, described by Walder (1941 : 245). The individual lenses are rarely thicker than 15 ft., and are separated by varying thicknesses of marl.

These beds are best developed near Acton Round where relatively coarse sandstones, intercalated with red and green marls, form a distinct feature. They are probably also present north and east of Morville where much of the solid geology is obscured by drift. Between Acton Round and Morville the sandstones are distributed throughout some 400 ft. of strata, the highest occurring 280 ft. below the main "*Psammosteus*" Limestone at Monkhopton. The Beaconhill Brook section shows the typically lenticular nature of the sandstones, many resting upon erosion surfaces cut into green marl. The individual beds are thin and seldom more than 50 yds. long, their basal layers usually containing water-rolled flakes of marl. Strong cross-bedding is general and suggests a predominantly northern derivation. A few local concentrations of fish fragments occur and include *Kallostrakon* and acanthodian remains. Westwards to Skimblescott the sandstones decrease in number, whilst between Skimblescott and Stanton Long only a few very thin friable sandstones have been found. At Holdgate a marked N.–S. scarp is formed by a coarse sandstone or group of sandstones, about 18 ft. thick, the top bed being some 650 ft. above the Ludlow Bone Bed. Further sandstones are developed at this horizon at Baucott, Culmington and Stanton Lacy. In the Ledwyche Valley dark, mottled sandstones occur near Fishmore Hall, Warthill and Brook House.

The uppermost 100 ft. of the Red Downton Formation include further coarse beds, localized in groups near the foot of the "*Psammosteus*" Limestones escarpment. Sandstones and cornstones here alternate with marls and are so similar to the Dittonian beds that they may be regarded as locally developed precursors to those of the Ditton Series. These beds are well exposed in Lye Brook, Morville, where some 100 ft. of strata occur below the limestone, the lowest conspicuous bed being a cross-bedded, white, pellety grit yielding *Traquairaspis symondsi* (Lankester). Above this, lenticular groups of thin cornstones and sandstones are exposed and occupy about 15% of the succession. Several prominent sandstone and cornstone bands can be traced along Meadowley Hill and Aston Hill, some of which have yielded *Pteraspis* (*Simopteraspis*) *leathensis* White; but, with the exception of Lye Brook 4, their exact relationship to the main "*Psammosteus*" Limestone is not certain since some of them are undoubtedly displaced by large-scale hill-creep and may be Dittonian. The cornstone near Yewtree Dingle (121)[1] yielding *Pteraspis* (*Simopteraspis*) *leathensis* White and other fossils, mentioned by White (1950 : 74, 75), is placed by King just below the "*Psammosteus*" Limestone and by Pocock (*in lit.*) 50 ft. above "a *Psammosteus* Limestone". However, each is probably referring to a different limestone,

[1] The numbers in parentheses after localities correspond with those given in the List of Fossil Localities and on the map

and it seems likely that the lower is the main limestone (see below). A coarse white grit similar to that in Lye Brook outcrops about 100 ft. below the only "*Psammosteus*" Limestone at Stapely Dingle, but the sections in Hudwick and Sudford Dingles, Monkhopton, show only a few thin impersistent sandstones in the red marls below the main "*Psammosteus*" Limestone. A thin red cornstone 25 ft. below the main limestone in Foxhole Coppice, Monkhopton (31), contains *Kallostrakon* and acanthodian remains.

Even in closely adjacent sections on the escarpment between Monkhopton and Tugford the successions differ, comparable sequences occurring in two only. The fossiliferous cornstone and underlying marl and "race" outcropping in Earnstrey Brook (25. See Wills, 1935) are exactly like the beds at the foot of the section near Little Oxenbold (51), two miles to the north-east and both horizons yield a rich fauna. Exposures between the two localities show red and green marls with occasional coarser beds. The sporadic outcrop of cornstones suggests restricted accumulation, perhaps in a stream channel.

At Bouldon rapidly alternating red and green shales and thin-bedded argillaceous sandstones and cornstones lie below the main "*Psammosteus*" Limestone. South and east of Bouldon only a few scattered, lenticular, barren sandstones and cornstones have been found near the top of the Red Downton Formation.

(b) *Ditton Series*

The Ditton Series comprises a sequence of closely alternating marls, silts, lenticular sandstones and cornstones, delimited by the main "*Psammosteus*" Limestone at the base and the lower Abdon Limestone above. However, as is pointed out below (p. 198), it may be necessary at some future date to redefine the top of the Ditton Series, since the uppermost 150 ft. may be coeval with the lower part of the Senni Beds (i.e. Breconian) of the Black Mountains, as defined by Croft on the basis of their flora. The Series can be broadly subdivided into two subsidiary groups, though owing to the lack of a mappable marker horizon the boundary between them is arbitrary. The lower group is lithologically similar to the uppermost Downton Series and principally bright red and green in colour. The upper group is more varied and like the lower part of the succeeding Clee Series, chocolate, buff-grey and orange tints being common, whilst many of the beds are strikingly coarse-grained. Thus, the following lithological subdivisions of the Ditton Series are recognized in the Brown Clee Hill area :

	(iii) Upper group of marls, silts, sandstones and cornstones	400–550 ft.
Ditton Series	(ii) Lower group of marls, sandstones and cornstones	800–900 ft.
	(i) Main "*Psammosteus*" Limestone	0–16 ft.
	Total	1,200–1,450 ft.

During the mapping of the area, local names were erected for convenience and applied to the lower and upper groups of the Ditton Series ; "Bouldon Beds" for the lower and " Wheathill Beds " for the upper. It is not proposed that these should be retained. However, the term " Wheathill Beds " was incorporated by Wills (1950 : 24, 30) in a classification of the Old Red Sandstone, though assigned by him to the Breconian owing to the alleged presence of " *Rhinopteraspis dunensis* ". This was due to uncertainty over the status of *Pteraspis* (*Cymripteraspis*) *leachi* originally described by White (1938) and hitherto recognized as a variety of *Pteraspis* (*Rhinopteraspis*) *dunensis* (s.s.), but which must now be treated as a separate species (White, 1950*a* : 56) and sub-genus (White, 1960 : 8). Thus, *Pteraspis* (*Rhinopteraspis*) *dunensis* (s.s.) has not as yet been recorded in the Clee Hills area.

The Ditton Series is best exposed in the several stream courses which drain westwards across the Ditton platform, especially where they cut into the " *Psammosteus* " Limestones escarpment. But even here the sequences are discontinuous, the upper part of the lower group and the upper group being poorly exposed. Hence it has proved impracticable to define a type section. The lowest beds of the lower group include a high proportion of sandstones and cornstones which give rise to a prominent escarpment, the so-called " *Psammosteus* " Limestones escarpment. This well-marked feature extends westwards from Underton, in the north-west of the area, along the eastern edge of Corvedale, to Tar Grove on the south-western margin of the Ledwyche Valley. The upper beds of the lower group include a larger amount of marls and form the broadly undulating surface which constitutes the greater part of the Ditton platform. The upper group incorporates a higher proportion of coarser beds which form the steeper footslopes of Brown Clee Hill and Weston Hill. To the north-west of Brown Clee Hill the Ditton Series has a thickness of 1,200 ft., comprising approximately 800 ft. of the lower group and 400 ft. of the upper. However, to the south-east of the hill the Series thickens to 1,450 ft., consisting of some 900 ft. of the lower group, which also includes more coarser beds in its upper part, and 550 ft. of the upper group. Around the head and eastern margins of the Ledwyche Valley, the " *Psammosteus* " Limestones escarpment merges with the generally steeper slopes resulting from the inclusion of a higher proportion of coarser beds in the lower part of the Series.

Between Brown Clee Hill and the Coal Measures of the Wyre Forest, delimited in the north by the " *Psammosteus* " Limestones escarpment and in the south by the northern slopes of Titterstone Clee Hill and the Farlow-Walton ridge, the Ditton Series forms a broad area of rolling country. Extending north-eastwards around Brown Clee Hill, the outcrops of the subdivisions of the Series expand rapidly, the lower group in general outcropping north of a line from Cleobury North to Deuxhill, the upper group largely occupying the area to the south of this line.

(i) *Main* " Psammosteus " *Limestone*

Since the earliest studies of the Anglo-Welsh Old Red Sandstone were made, the presence of a group of widely distributed, distinctive limestones, the " *Psammosteus* " Limestones, lying immediately above a thick marl division, has been known. Several workers have used them as marker horizons, Whitehead & Pocock (1947 : 7, 8) defining them as demarcating the base of the Ditton Series in the north-east of the area.

McCullough (1870 : 35) noted that one apparently continuous limestone could be traced for some distance in the Pontrilas district. More recently White (1946, 1950*a*) has discussed the derivation, validity and continued use of the name " *Psammosteus* Limestones " and has suggested that they may be diachronous. The general characteristics of their lithology have been described (recent notes have been added by White, 1946; Dineley, 1951 and *in* Ball & Dineley, 1952), but a detailed petrographical study is still greatly needed. Fleet (*in* King, 1925 : 385) demonstrated that they are relatively pure limestones and that their inorganic nature seems to be substantiated by the complete absence of fossils.

The distribution of these limestones throughout the Brown Clee Hill area has been mapped with two aims in view, to ascertain (*a*) their reliability as marker horizons, and (*b*) whether they are diachronous. More than one limestone is exposed in several sections on the " *Psammosteus* " Limestones escarpment, but the principal horizon is usually 5 ft. or more thick, reaching 16 ft. at The Hope. The other limestones are generally much thinner, impersistent and nodular, and also more argillaceous and less compact. Where the position of the main limestone was uncertain it has proved possible to locate it with a " Megger " earth-tester, following the technique used by D. W. Gossage whilst mapping the " *Psammosteus* " Limestones near Cleobury Mortimer (Dineley & Gossage, 1959 : 227–229). Elsewhere small excavations have been made to determine the position of the limestone, and at only a few points has no limestone been detected. The " *Psammosteus* " Limestone outcrop given on the map is here regarded as the main limestone.

Two limestones are recorded in a small inlier in Borle Brook, near Criddon Bridge (Pocock & Whitehead, 1947 : 22) and between Underton and Lye Brook, the upper being only poorly developed and continuing westwards to Moor Dingle, rising from 400 ft. O.D. at Underton to 480 ft. at The Lye. The lower limestone outcrops at a number of points along the escarpment between Meadowly and Moor Dingle and attains a thickness of 10 ft. near Monkhopton, but in Hudwick Dingle it wedges out and reappears within a few yards. Both nodular and massive limestone occurs in Sudford Dingle. From Foxhole Coppice to Oxenbold Coppice there is only one limestone, infrequently exposed, but detected by the " Megger " earth-tester and maintaining a constant level at about 700 ft. O.D. No limestone has been detected in Oxenbold Coppice, but from its southern end a thick limestone can be followed southwards between 500 and 600 ft. O.D. into the Ledwyche Valley, rising north-eastwards to 650 ft. near Gibbridge where it is faulted down 90 ft. to the east. A little further to the east, it is downthrown some 150 ft. to the south-east by the Brown Clee Fault, but rises to nearly 800 ft. at Langley, its easternmost outcrop in the valley. South-westwards from Stantongate the limestone reaches an elevation of 900 ft. O.D. on the western flank of Titterstone Clee Hill, then descends to 700 ft. at Bitterly, a mile to the south.

Only one limestone appears to be persistent throughout the Brown Clee Hill area. It is irregular in thickness and locally absent, like a sheet with holes and thin patches. This bed, referred to as the main " *Psammosteus* " Limestone, is here regarded as an important marker horizon, defining the base of the Ditton Series. Thinner, impersistent limestones are locally, but not extensively, developed.

(ii) *Lower Group of Marls, Sandstones and Cornstones*

The best exposures in the lower group of the Ditton Series occur in its lower part, particularly along the streams cutting through the " *Psammosteus* " Limestones escarpment. One of the most continuous sections occurs in the stream draining from Cockshutford to Tugford, where approximately 60% of the exposed strata consists of marls, though the true proportion of these is probably nearer to King's estimate of 70% (1934 : 529). The marls in the lower part of the group are predominantly red and purple in colour, the latter generally being highly micaceous, with numerous layers and lenticles of green marl. Silty marls also occur, particularly in the upper part of the group, and tend to be duller and slightly browner. Both types frequently contain ramifying pipes and veins of purple marl, and erosion surfaces are common where marls are overlain by sandstones. The marls also incorporate lenticles of " race " and variegated, concretionary limestones. Near the top of the group two thin bands of limestone, lithologically identical with the Abdon Limestones, occur near New Earnstrey Park.

The sandstones of the lower group of the Ditton Series are almost invariably fine-grained, though as pointed out by King (1934 : 528) they are generally coarser and much less micaceous than those of the Downton Series. The sandstones are principally red- and purple-brown in colour, with many green bands, and are frequently calcareous and hard, sometimes incorporating sandy, calcareous nodules. They are characteristically current-bedded and frequently show ripple-marked bedding planes, whilst desiccation-cracks, (?) animal tracks, and other trace fossils have also been recorded. Sole markings occur in many of the sandstones and are clearly of more than one type. Most conspicuous are the impressions of erosion surfaces, with small washouts and sandstone piping, but possible post-depositional structures also occur. A few thin bands of coarse grit occur, particularly in the " *Psammosteus* " Limestones escarpment.

Associated with the sandstone bands are lenses of cornstones, commonly composed of pellets of red-brown marl, and red, grey and yellow-buff marly limestones set in a marly, silty or occasionally sandy, calcareous matrix. The size of the pellets varies widely, typically between 0·5 and 1·5 cm. in length, though ranging up to 8·0 cm. Some of the cornstones incorporate angular or sub-angular pebbles of vein quartz, and many include fragments and scales of ostracoderms. Lenses of green cornstones also occur, usually less calcareous than the preceding cornstones, being composed of pellets of green and olive marl, sometimes calcareous, in a green marl or sand matrix. Such cornstones are generally found associated with green sandstones and frequently incorporate small quartz pebbles and carbonized plant remains.

Passing up the sequence, the lower group of the Ditton Series becomes duller and more silty, and the relative proportion of marls increases. King's "*Cephalaspis* Sandstones ", present in the Trimpley inlier, cannot be distinguished in the Brown Clee area, and no marker horizons have been detected in the Ditton Series above the main " *Psammosteus* " Limestone. Thus, though both the upper and lower groups have distinctive faunas and in general the upper group is marked by an increase in the amount of sandstones and cornstones, the junction between them is arbitrary.

The best section in the lower part of the lower group occurs in Hudwick Dingle where sandstones and cornstones constitute about 52% of the measured succession of 220 ft., a higher proportion than in other nearby sections.

The junction of marls with overlying sandstones is here usually sharp, frequently uneven, sometimes consisting of an erosion surface beneath which the marls are stained green to a depth of 2 to 3 ft. Cornstones are developed at the base of many sandstones, which are as a whole much less micaceous than the Downtonian sandstones. Cross-bedding is common and oscillation ripple-marks are found in a number of the higher beds. No desiccation-cracks have yet been found in the succession in Hudwick Dingle, but in the lower part bands of " race " and thin argillaceous limestones occur. A thick cornstone immediately above the main "*Psammosteus*" Limestone (37) has yielded a large fauna, including *Traquairaspis symondsi* and *Pteraspis* (*Simopteraspis*) *leathensis*. The latter also occurs at an horizon some 80 ft. higher (39), whilst *Pteraspis* (*Pteraspis*) *rostrata* var. indet. is found at 175 ft. above the limestone (40).

Coarse beds constitute about 43% of the strike section, vertical thickness 100 ft., occurring above the main "*Psammosteus*" Limestone in Borle Brook between Upton Cressett and Wallsbatch, and lying in the zone of *P.* (*S.*) *leathensis*. Several thin sandstones and cornstones are exposed in Rea Brook, which are disrupted by small faults and thrown into small sharp folds, in the vicinity of Middleton Priors.

The outcrop of thick sandstones and cornstones in the lower part of the Ditton Series on the western side of Brown Clee Hill, gives rise to well-defined local features, particularly at Bouldon and Sutton Hill. Stream sections along the "*Psammosteus*" Limestones escarpment between 700 and 800 ft. O.D. expose sequences of rapidly alternating marls, sandstones and cornstones, dipping south-eastwards at 5 to 10 degrees, the marls forming about 60% of the total. Many of the cornstones are extremely coarse containing pellets up to 10 cm. in length. A good section outcrops in Kidnall Gutter, Tugford, where the main "*Psammosteus*" Limestone is particularly well exposed. The Kidnall Gutter section is noteworthy for having yielded *P.* (*P.*) *rostrata* var. indet. from a cornstone 15 ft. above the main "*Psammosteus*" Limestone (44) with *P.* (*S.*) *leathensis* occurring a further 15 ft. above (45). The stream bifurcates in its upper reaches and the contrast between the two resultant sections illustrates the rapidity of lateral change within the beds. This is also well shown in Oak Dingle (75), Tugford, where a green cornstone-sandstone, estimated to lie about 125 ft. above the main "*Psammosteus*" Limestone, has yielded *Pteraspis* (*Pteraspis*) *rostrata* var. *trimpleyensis*, *Traquairaspis symondsi* and *Tesseraspis*. Several small structures resembling spring-pits (Shrock, 1948 : 136) occur in a sandstone at the foot of the section.

The sections in Clee and Abdon Brooks are poor, the scattered exposures largely consisting of red and green marls with a few green sandstones and cornstones. Old quarries on the escarpment near Bouldon expose sections in buff and olive shales and sandstones and extremely coarse cornstones. A cornstone exposed in Clee Brook at Bouldon (13) about 50 ft. above the main "*Psammosteus*" Limestone, has yielded *Pteraspis* (*Pteraspis*) *rostrata* var. *trimpleyensis*, whilst a very coarse cornstone outcropping in the Old Forge Quarry (77), Bouldon, is possibly the same as that occurring 24 ft. above the main "*Psammosteus*" Limestone in Strand Brook, three-quarters of a mile to the south. The quarry at Hoptongate (36) shows an exceptional sequence of 8 ft. of green, argillaceous cornstone in thin, successive, cross-bedded lenticles, many of which have truncated upper surfaces. The fine section in Tar Grove Quarry (105), east of Whitbatch and about 175 ft. above the main "*Psammosteus*" Limestone, has yielded *P.* (*P.*) *rostrata* var. *trimpleyensis* and *T. symondsi* from the same stratum, this being the highest record of the latter.

The middle and upper parts of the lower group are poorly and intermittently exposed in stream sections to the west of Brown Clee Hill, and in Ledwyche Brook and Newton Dingle near whose confluence thick sandstones and cornstones occur. The beds are sparsely fossiliferous, but have yielded *P.* (*B.*) *crouchi*, *P.* (*P.*) *rostrata*, *P.* (*P.*) *dairydinglensis* and arctolepids. Bright red and green marls with thin cross-bedded sandstones and cornstones of the lower group outcrop in the "saddle" between Bromdon and Titterstone Clee Hill and extend eastwards into the Silvington Valley where they have yielded *P.* (*B.*) *crouchi*. There appears to be considerable faulting in this region and the exact thickness of the lower part of the Ditton Series here is uncertain.

The lower group of the Ditton Series equates with the *leathensis* and *crouchi* Zones.

(iii) *Upper Group of Marls, Silts, Sandstones and Cornstones*

The transition from the lower group to the upper is marked by a sharp break in fauna, though further intensive collecting may prove that the faunal dichotomy is not so distinct as that implied by present evidence. Furthermore, there is an increase in the proportion of sandstones and cornstones, and also in the coarseness of grade, marls being replaced to a large extent by silts and silty shales, whilst the upper beds become red-brown brown-buff and grey-green in colour. The trend in increasing coarseness of grade upwards in the succession, shown by the Downton Series and the lower group of the Ditton Series, is continued in the upper group of the latter. Thus, in the lower part of the upper group, marls and silts predominate over sandstones and cornstones. However, the proportion of the latter increases in the upper part and yellow- and brown-buff silts become increasingly common.

The marls of the upper group are predominantly chocolate and green in colour; the silts are red-brown, buff, grey and green, frequently laminated, and often incorporate sandy, calcareous concretions, nodules of argillaceous limestone and purple "piping". The sandstones are largely fine-grained or silty and predominantly red-brown, grey, chocolate and pale-buff or green in colour. Some of the sandstones are calcareous, hard and thickly bedded, whilst others are laminated and silty, incorporating scattered marl pellets and sandy, calcareous concretions. Current-bedding is common and many of the sandstones are markedly lenticular. Cornstones are most common in the upper group and show considerable variation in lithology. They frequently have a yellow-buff hue, though they are also red, green and grey, being composed of pellets of yellow-, orange- and chocolate-buff, red-brown, grey and purple calcareous marl and argillaceous limestone. The matrices vary from argillaceous or sandy limestone, which has sometimes become recrystallized, to marl, when the boundaries of individual pellets are frequently difficult to distinguish. The pellets are largely sub-rounded to sub-angular and average 1 to 2 cm. in size, though ranging up to 7 cm. The cornstones are commonly current-bedded and well sorted, the pellets in any given band being of approximately the same size. Some consist of rapidly alternating well- and poorly-sorted lenses, the latter usually being much more marly than the former. The green cornstones are frequently very argillaceous and rubbly, and incorporate much carbonaceous plant debris. A few thin, grey, concretionary limestones occur which are lithologically similar to the "*Psammosteus*" Limestones.

The outcrop of the upper group of the Ditton Series occupies the broad and undulating area to the east of Brown Clee Hill, approximately between Upper Overton and the Farlow-Walton ridge, and forms the footslopes of Brown Clee Hill and Weston Hill. Exposures in the group are few and poor, being either short, discontinuous sections along stream courses and road cuttings, or small isolated quarries. The best section occurs along Bensons Brook, Titterstone Clee Hill, which lies outside the area being described ; but within the area, the most complete section is exposed in Newton Dingle on the southern slopes of Brown Clee Hill. In Newton Dingle, in the area of The Gore, a succession of marls, laminated siltstones and cornstones outcrops, two of the cornstones having yielded *Pteraspis* (*Cymripteraspis*) *leachi* White and, in one instance, *Protaspis* (*Europrotaspis*) *crenulata* sp. nov., whilst plant fragments occur at several horizons in laminated siltstones and sandstones. North of The Gore, the sequence is less well exposed but includes purple, green and buff, silty sandstones and siltstones, with a few bands of rubbly cornstone.

The thick bands of cornstone and sandstone, characteristic of the group, give rise to prominent features such as The Thrift, the col which links Brown Clee Hill with Weston Hill, and the succession of small escarpments in the Wheathill-Silvington area. The scarp slopes face north-west and an outcrop near the top of the slope occurring 1,200 yds. north-east of Silvington (93) reveals a massive cornstone, some 14 ft. thick, dipping to the south-east. Sections in sandstones and cornstones also occur in road cuttings at Clee St. Margaret, Stoke St. Milbrough, Wheathill and north of Farlow Bank. Cornstones at several localities have yielded the characteristic fauna of *Pteraspis* (*Cymripteraspis*) *leachi* and *Protaspis* (*Europrotaspis*) *crenulata*, with numerous arctolepid fragments, and a notable locality (8) near to Besom Farm has yielded *Benneviaspis salopiensis* sp. nov., the youngest cephalaspid yet recorded in this area (see p. 282 ; also Ball & Dineley *in* Whittard, 1953 : 249, 250). Many of the laminated siltstones have yielded plant fragments, though these are poorly preserved and largely indeterminable. However, the late W. N. Croft was able to recognize *Prototaxites*, *Pachytheca*, leaf-like patches of *Nematothallus* and slender branched axes, cf. *Cooksonia*, from an assemblage collected from a small outcrop in silty sandstones at Dodshill Bank (23), half a mile to the south of Besom Farm.

The top of the upper group is exposed in a small quarry 200 yds. north of Walton (114), where the lower Abdon Limestone, which forms the base of the Clee Series, is interbedded with some 15 ft. of sandstones and cornstones. The sandstones include grey and chocolate-grey, massive, hard bands and also buff, silty beds ; whilst the cornstones are red- and green-grey in colour and very gritty, that immediately below the Abdon Limestone having yielded to King a fragment of an arctolepid and an acanthodian scale, the highest record of ostracoderms in the area.

The upper group of the Ditton Series equates with the zone of *Pteraspis* (*Cymripteraspis*) *leachi* White.

(c) *Clee Series*

The base of the Clee Series is here defined as the bottom of the lower of two major limestone horizons which, with the intervening strata, form a prominent feature around the north-western slopes of Brown Clee Hill. This lower limestone horizon is a fairly consistent and mappable feature, and below it the beds are, in general, more typically Dittonian in aspect than those above which rapidly assume the characteristic Clee Series lithology. The upper limestone is also relatively persistent and lies some 200 ft. above the lower. Since both limestones are especially well developed in the area of Abdon where they have been extensively quarried in the past, King has called them (*in lit.*) the Abdon Limestones, and this name will be retained here.

Both horizons show rapid lateral and vertical variations in lithology, from massive to nodular limestones, and calcareous marls somewhat like the " race " of the Downton and Ditton Series. The massive limestones are generally dark brown and brown-purple in colour when fresh and often include a few angular grains of quartz averaging 0·2 mm. in size, with rarer grains of plagioclase feldspar, microcline, tourmaline, zircon, garnet, muscovite, cherts and " felsite ". With an increase in arenaceous material the limestone passes into calcareous and frequently lustre-mottled sandstone. Variations of the massive limestone facies also occur. Much of it appears to have been deposited as a relatively homogeneous calcareous mud showing in thin section signs of movement in a plastic state. Another common variation consists of angular, brown, grey and brown-purple limestone fragments ranging up to 10 cm. in size, set in a like matrix, possibly originating from the pene-contemporaneous breaking up of thin sheets of calcareous mud with rapid re-cementation. The third variation appears to be concretionary in origin (cf. the " *Psammosteus* " Limestones) and sometimes distinctive problematical structures (p. 198) are found associated with it. With an increase of marl and silt the concretionary limestones pass into the nodular facies and ultimately into a calcareous marl, both commonly variegated.

Concomitant with rapid changes in facies, the limestones vary in thickness. The greatest development appears to be along the lower slopes of Brown Clee Hill above Abdon, where the lower limestone is at least 10 ft. thick, Murchison (1833 : 473) recording a thickness of 18 to 20 ft. The outcrop is marked by a succession of small quarries (Murchison, 1839 : 179, 180) now largely overgrown, which extend round the foot of the hill to a point near Hillside Farm, where the limestone is very nodular and marly, and interbedded with lenses of calcareous marl and red-brown calcareous sandstone, or white, lustre-mottled sandstone. To the south of Abdon Liberty the outcrop of the lower horizon is marked by a number of smaller workings which become more sporadic towards Cockshutford, where the limestone is frequently replaced by calcareous sandstones, often white and lustre-mottled. South of Nordybank it appears to be intermittently replaced by calcareous sandstones as far as Pel Beggar, where the limestone becomes re-established in its nodular facies and can be traced eastwards to the south of Bockleton Court. To the south-west of Pel Beggar, a small outlier of the lower limestone caps Weston Hill. At Bockleton Court both horizons are displaced to the south by the Brown Clee Fault, but owing to solifluction the outcrop of the lower is difficult to trace east of the fault, though it is in part marked by overgrown workings and outcrops in the track leading to Shortwood. Nowhere beyond this point along the eastern side of the hill has the lower limestone been detected. Thus the base of the Clee Series on the eastern slopes of Brown Clee Hill has been extrapolated and is wholly conjectural.

The upper limestone, whilst not reaching the thickness of the lower at its maximum, undergoes similar variations in thickness and lithology, and is much more persistent. At Abdon Liberty and along the northern slopes of the hill, the upper limestone forms a prominent rib above the quarries in the lower, and has itself been quarried on a small scale. The trace of the outcrop becomes less pronounced on the north-eastern slopes of the hill, where the limestone becomes more nodular and marly, as can be seen in the old workings at Cleobury North Liberty. South of Abdon Liberty the outcrop is marked by further small workings, whilst between Cockshutford and The Sands the upper limestone has been quarried on a scale commensurate with that of the lower limestone workings on the northern slopes of the hill. The best exposure in the Abdon Limestones occurs in the upper horizon at Cockshutford where it has been exposed by recent quarrying. The upper limestone outcrops in small workings to the north of Bockleton Court where it is displaced to the south by the Brown Clee Fault. East of Bockleton Court it forms a prominent feature which extends round the south-eastern slopes of the hill to Banbury, having been extensively quarried near The Toot. Like the lower limestone, the upper has not been detected on the eastern side of Brown Clee Hill between Banbury and Cleobury North Liberty.

The strata between the Abdon Limestones consists largely of sandstones and silty shales, predominantly red-brown at the lower levels, becoming increasingly buff and grey in colour upwards, which with the limestones form a distinct feature at the foot of the northern and western slopes of Brown Clee Hill. The sandstones are composed dominantly of quartz, both igneous and metamorphic, the grains being largely sub-angular to angular but also sub-rounded and occasionally rounded. The grains range in size from 0·01 mm. (fine silt) to 0·1 mm. (coarse sand) but average between 0·1 and 0·4 mm. (fine to medium sand) ; most of the sandstones being moderately well sorted. Also incorporated are frequent grains of plagioclase feldspar in the albite-oligoclase range, myrmekite, perthite and microcline, and fragments of a variety of rock types including " felsite ", basalt, volcanic glasses, quartz schist, cherts and calcareous marls. The feldspars are largely fresh but some are undergoing sericitization. Accessory minerals include worn zircons, white mica, chlorite, tourmaline, garnet and epidote. Cementation is largely by calcite or ferruginous mud. In some of the calcareous sandstones, the component grains do not form a mesh and were probably deposited by lime-rich waters as a sandy, calcareous mud which has undergone subsequent recrystallization. Some of the quartz grains have been strained and fractured during recrystallization, whilst others have been partially replaced by calcite. Intercalated with the sandstones and silts are lenses of massive and nodular limestones identical with the Abdon Limestones, and variegated calcareous marls.

Succeeding the Abdon Limestones are some 700 ft. of strata consisting largely of sandstones and silts (estimated 85 to 90%) and forming the greater part of the Clee Series. The sandstones are commonly current-bedded and predominantly grey, buff, brown and purple in colour, and though similar in composition to those between the limestones they tend to be coarser, with grain size averaging 0·4 to 0·75 mm. The succession as a whole becomes coarser upwards, with the appearance in the upper part of coarse sandstones and grits.

A large number of the sandstones incorporate pellets and pebbles of variegated calcareous marls, many of which cannot be matched with the marl bands intercalated with the sandstones. The pellets are typically between 1 and 6 cm. in size, but range up to 16 cm., and occur throughout the succession. In contrast, pebbles of vein quartz, yellow and liver-coloured quartzite and cherts are especially common in the upper part of the Clee Series. A derived Silurian polyzoan, *Fistulipora* sp., was found as a pebble in the lower part of the Clee Series at the head of Batch Gutter, 320 yds. north-west of The Toot, but it has not proved possible to assign it to an horizon within the Silurian. Though predominantly sub-angular, some rounded pebbles do occur, and these are usually less than 3 cm. in size. However, like the constituent grains of the sandstones, the pebbles increase in size upwards in the succession, one pebble of 22 cm. having been found in the upper part of the Clee Series. A few bands are entirely composed of pellets and fragments of grey and green calcareous marl with small pebbles of vein quartz, and are comparable with the cornstones of the Downton and Ditton Series. Intercalated with the sandstones are occasional lenses of silty marl, usually purple and green in colour, and variegated, calcareous, nodular marls, some of which grade into nodular limestones similar to the nodular facies of the Abdon Limestones. Rapid lateral facies variation and lensing-out of beds is characteristic of the group as a whole, though many of the strongly developed sandstones in the upper part of the Clee Series are more persistent and form a succession of well-marked features along the western slopes of Brown Clee Hill.

The Clee Series is best exposed along the streams draining the western and south-western slopes of Brown Clee Hill. The most continuous section occurs along the stream course extending north-westwards from Clee Burf to Cockshutford, whilst other relatively good, but more broken sections, can be seen along the streams flowing westwards from Five Springs and south-westwards from Warren Cottage. Numerous small exposures occur on the northern, western and southern slopes of the hill, but are almost entirely lacking on the east. The full development of the Clee Series is not seen since it is sharply truncated by the plane of the Coal Measures unconformity, but its maximum thickness as exposed on the western slopes of Brown Clee Hill is calculated to be 900 ft.

A further small outcrop of the Clee Series occurs as a downfaulted wedge at Walton, in the south-east of the district. A limestone some 3 to 4 ft. thick outcrops in a small quarry 200 yds. to the north of Walton, (114). It is identical with the massive facies of the Abdon Limestones and containing, in addition, the same distinctive problematical markings. The line of outcrop of a similar limestone was revealed by deep ploughing in fields to the south of Walton. Since the latter is calculated to be some 200 ft. above the first limestone it seems probable that they represent the Abdon Limestones. The associated sandstones and silts show a typical Clee Series lithology.

The Clee Series has, as yet, yielded no indigenous fauna or flora. However, as has been stated above, certain problematical markings appear to be confined to the Clee Series, occurring in the Abdon Limestones, in some of the sandstones between them, and continuing at least into the middle of the Series. The markings are identical with those first noted by Croft (Pocock, Brammall & Croft, 1940 : 55) as " pepper-pot " markings in the Senni Beds and subsequently recorded by him as " distinctive problematical structures " confined to these beds and occurring throughout the Black Mountains and neighbouring areas (Croft, 1953 : 431). Despite this absence of diagnostic fauna or flora from the Clee Series, there are strong stratigraphical grounds for correlating them with the Senni Beds of South Wales. Both show similar gradational changes from the Dittonian strata which they overlie conformably (Croft, 1953 : 429), with an increase in the proportion of sandstones and change in colour from predominantly reds and purples to greens and greys. Moreover King has long recognized the close similarity between the Abdon Limestones and the Fynnon Limestones of the Black Mountains. In both areas there are two major limestone horizons separated by some 200 ft. of strata, and all are lithologically alike (King *in lit.*).

It should be noted that the base of the Clee as defined above does not correspond with that of the Senni Beds as defined by Croft (*in lit.*), which is at the bottom of a prominent group of sandstones containing a typical Senni Bed flora (Croft & Lang, 1942) extending a short distance below the lower Fynnon Limestone. As yet, the equivalent strata occurring below the Abdon Limestones have not yielded a flora, but if the correlation between the Abdon and Fynnon Limestones can be substantiated and they are not diachronous, it will be necessary to re-define the top of the Ditton Series. Similarly it has been impossible to draw an upper limit to the Clee Series corresponding with the Senni Beds-Brownstones boundary in the Brecon Beacons. Thus it is expedient to retain for the Shropshire Breconian strata the local name of Clee Series until a more exact correlation is possible.

The presence of true Brownstones, namely, strata succeeding the Senni Beds and underlying the Farlovian (Croft, 1953 : 429), cannot be proved in the Shropshire area. But since Croft gives a thickness of 850 ft. for the Senni Beds in Breconshire, and in view of the general correlation between the Clee Series and the Senni Beds, the Brownstones may well be represented by the highest beds of the Clee Series on Brown Clee Hill. The " Brownstones " previously recorded in the area (King, 1925 : 383, 388 ; Edmunds & Oakley, 1947 : 27 ; Whitehead & Pocock, 1947 : 23, 24 ; Pocock & Whitehead, 1948 : 66 ; Wills, 1948, 1950) have proved to be largely of Upper Dittonian age and, in part, lower Breconian. White (1956 : 5) has suggested that the Senni Beds are probably of Middle to Upper Siegenian age, which is therefore true for the Clee Series.

FAUNA AND FLORA

The Downton and Ditton Series are largely barren, though there are a few relatively fossiliferous horizons, particularly the cornstones and sandstones associated with the "*Psammosteus*" Limestones. The fossils are frequently concentrated into lenticles, sometimes forming veritable bone beds. The major part of the fauna consists of ostracoderms, invertebrates being rare, especially in the Ditton Series. The associated flora is poorly preserved. With the possible exception of the problematical structures they contain, the Clee Series appear to be entirely barren.

(a) *Vertebrates*

The Lower Old Red Sandstone of the Clee Hills area has long been known for its ostracoderm fauna, notable collections having been made in the last century by G. Cocking, Rev. J. F. Crouch, Dr. J. Harley, Rev. T. T. Lewis, R. Lightbody, Dr. T. Lloyd, A. Marston and H. Salwey; and more recently by Dr. E. I. White, H. A. Toombs, Prof. L. J. Wills, and especially the late W. Wickham King. The localities yielding ostracoderm remains are recorded on the map and are listed below. Many of the classic localities which yielded rich faunas in the past now appear to be completely barren, e.g. Whitbach, near Ludlow, which was re-excavated for the 1948 International Geological Congress Excursion C.16, and yielded not a single fragment.

The number of forms present in the fauna is large, and the writers are greatly indebted to Dr. E. I. White for the faunal determinations and for his description of the new forms which it contains. The delicate and laborious preparation of the material has been undertaken by Mr. H. A. Toombs utilizing the acetic acid technique (Toombs & Rixon, 1959). This has revealed incidentally that some of the cornstones incorporate a rich and diversified micro-fauna.

Mode of Occurrence of the Vertebrate Fauna

In his description of the remarkable faunule at Wayne Herbert, Herefordshire, White (1935) was among the first to appreciate the necessity of carefully evaluating the mode of occurrence of ostracoderm faunas. His later studies also emphasized the peculiar nature of the distribution and composition of these faunas, and he suggested (1950*a* : 57, 58) that the vertebrate faunas (faunules) are spasmodic introductions from a plexus of streams emptying into a common basin. This is substantiated by the occurrences in the Clee Hills area, thus:

1. the ostracoderm remains are usually concentrated into small lenticles;
2. the fossils most frequently occur in cornstones which rest on erosion surfaces and show signs of rapid deposition;
3. most of the remains are fragmentary, complete and undamaged carapaces being very rare;
4. the remains are frequently concentrated into residues of fragments of a similar size, buoyancy or weight;
5. the composition of each faunule tends to be distinctive and unique.

As noted above, the cornstones are generally the most fossiliferous, the sandstones being less so, whilst at only two localities have ostracoderms been found in marls.

The largest and most complete remains are frequently found in the bottom few inches of a cornstone, though they are often distorted and damaged by compression and compaction. The base of a conglomeratic, coarse, white grit at Lye Brook, which rests upon an erosion surface, has yielded the following fragments of *Traqairaspis symondsi* :

Dorsal shields . . .	4 relatively complete.
	4 large fragments.
Dorsal spines . . .	26 fragments.
Ventral shields . . .	13 relatively complete.
	17 large fragments.
Lateral plates . . .	13 relatively complete.
Orbital plates . . .	12 relatively complete.
Rostrum	1 incomplete.
?Branchio-cornual plate .	3 incomplete.
?Pineal	1 incomplete.
Scales (flank) . . .	2.

A number of small fragments were also incorporated, as well as *Tesseraspis*, *Kallostrakon*, and acanthodian spines. In the finer sediments above, only very rare small fragments occur. At least 26 individuals are represented, but only 8 dorsal shields and 1 rostrum are incorporated. It is probable that this selective concentration has been effected by current action. At Netchwood Common (62), 36 rostra of *Pteraspis* (*Belgicaspis*) *crouchi* were collected from about 8 sq. ft. of a cornstone 8 to 10 in. thick, though an even more remarkable concentration of plates has been recorded by White (1938 : 102) in Carmarthenshire.

Wills (1948 : 28) and White (1950 : 73) commented upon a cornstone slab from Morville which incorporated 30 dorsal and 3 ventral shields of *Pteraspis* (*Simopteraspis*) *leathensis*. The lithology of the cornstones suggests rapid deposition and supports White's hypothesis of a fluviatile deposition rather than Wills' suggestion of accumulation in a pool. White further notes that a more or less uniform orientation of plates may occur on a bedding plane, which also suggests transport in, and by, continuously moving water currents.

Most of the larger pteraspid fragments are of dorsal or ventral shields ; branchial and other paired plates may occur intact or broken, yet still attached to the shield, and where detached they are usually imperfectly preserved. The fragments usually show little sign of post-mortem attrition, and where abrasion is present it appears to have occurred during life on those parts of the plates which would be expected to come into contact with the river bed. No complete specimens as recorded by White (1935 : 383) at Wayne Herbert, Herefordshire, have been found. There, the evidence suggested essentially quiet deposition, possibly in a pool. Ostracoderm remains occurring in the finer sediments of the Clee Hills area are rare and usually fragmentary, the fossiliferous marls at Earnstrey Brook (25) and Little Oxenbold (51) being exceptional.

A remarkable feature of the traquairaspid and pteraspid faunules is that each is composed of individuals which are at approximately the same stage of development though they may show some degree of variation in form. Moreover, only rarely is one species of *Pteraspis* found in association with another, which may imply that the species occupied different ecological zones (see p. 252).

Utilizing the pteraspid faunas, White (1950, 1956) has erected a zonal sequence which has enabled the correlation of the Lower Old Red Sandstone of the Anglo-Welsh area with that of the continent. The present research has facilitated the more accurate definition of the limits of these zones within the type area, and the establishment of characteristic zonal assemblages. However, in view of the range within the type area of *P. rostrata* and also of its confused taxonomic status (see p. 247), White's zone of *crouchi* and *rostrata* is here referred to as the zone of *crouchi*. Moreover, it should be noted that throughout this work where reference is made to *Pteraspis* (*Pteraspis*) *rostrata* Agassiz, this does not indicate that the specimen referred to is *rostrata* s.s., but instead, *rostrata* var. indet.

(b) *Succession of the Vertebrate Fauna*

(i) *Downton Series, Red Downton Formation*

Zone of *Traquairaspis symondsi* (Lankester)

Of the small number of fossiliferous localities found in the Red Downton Formation, the great majority occur within the top hundred feet, being associated with the sandstones forming the lower slopes of the " *Psammosteus* " Limestones escarpment. White (1946 : 214 ; 1950 : 55 ; White & Toombs, 1948 : 5) has shown that the upper part of the Downtonian can be subdivided into two zones, a lower with *Traquairaspis pococki* and an upper with *T. symondsi*. However, since the two species occur together near Clifton-on-Teme, and *T. symondsi* has been found 100 ft. below, and *T. pococki* 17 ft. below what is considered to be the same limestone horizon at Gardners Bank (Dineley & Gossage, 1959 : 232), it is evident that the two forms overlap. Their mutual exclusiveness within the zone of overlap (with the exception of Clifton-on-Teme) may indicate, as in the pteraspids, that they occupied different environments.

Only *T. symondsi* has been found in the Brown Clee Hill area. It occurs at five localities, the lowest, Lye Brook (55), being 125 ft. below the main " *Psammosteus* " Limestone, which broadly accords with White's (1950*a* : 55) suggestion of a thickness of up to 150 ft. for the zone of *T. symondsi*. Below this level the sandstones and cornstones are largely replaced by marls, and it seems probable that the zone of *T. pococki* is represented by unfossiliferous strata.

The fauna associated with the zone of *Traquairaspis symondsi* has been recorded by White (1950*a* : 56) as comprising *Anglaspis*, *Corvaspis*, *Tesseraspis*, *Didymaspis*, *Cephalaspis*, *Ischnacanthus*, *Onchus*, *Onychodus*, *Kallostrakon*, *Thelodus*, to which must be added a single anaspid scale from Targrove Dingle 6 (104. See also Woodward, 1948). Most of the elements of the fauna occur in the *pococki* Zone, or in the succeeding zone of *Pteraspis* (*Simopteraspis*) *leathensis*. However, both *Corvaspis* and *Anglaspis* appear in the *symondsi* Zone and, near the top, *P.* (*S.*) *leathensis* and *Poraspis*, in association at New Inn 1 (71) ; whilst *Kallostrakon* does not appear to extend beyond it. Thus, the faunal assemblage characteristic of the *symondsi* Zone is *T. symondsi*, *Corvaspis*, *Anglaspis*, *Tesseraspis*, *Ischnacanthus wickhami* (see pp. 262–264) and *Kallostrakon*.

(ii) *Ditton Series*

Zone of *Pteraspis* (*Simopteraspis*) *leathensis* White

The base of the Ditton Series is marked by a distinctive lithological feature, the " *Psammosteus* " Limestones, and an important faunal change, the replacement of *Traquairaspis* by *Pteraspis* (White, 1950*a* : 56). Although *P.* (*S.*) *leathensis* occurs below the " *Psammosteus* " Limestones, and *T. symondsi* just persists into the bottom of the zone of *P.* (*B.*) *crouchi*, as can be seen from Table 1, *T. symondsi* is largely concentrated below the limestones and is rare above them (see also White, 1950*b*: 74). A further important form occurring with *P.* (*S.*) *leathensis* is *Pteraspis* (*Pteraspis*) *rostrata* var. *trimpleyensis* White, which appears about the middle of the *leathensis* Zone and persists into the lower part of the succeeding zone of *P.* (*B.*) *crouchi* ; moreover *P.* (*P.*) *rostrata* var. indet. occurs near the base of the *leathensis* Zone at Kidnall Gutter, 1 (44).

The earliest arctolepid (cf. *Kujdanowiaspis* sp.) in the area is recorded from the bottom of the *leathensis* Zone, at Criddon Bridge (19).

In addition to these, the fauna associated with the *leathensis* Zone is relatively large (White, 1950*a*), consisting of *T. symondsi*, *Corvaspis*, *Anglaspis*, *Poraspis*, *Tesseraspis*, " *Ischnacanthus* ", *Gomphodus*, *Onchus*, *Cephalaspis*, and acanthodian and thelodont scales. Several of these forms occur in the preceding and succeeding zones, but the assemblage which may be regarded as typical of the *leathensis* Zone is *P.* (*S.*) *leathensis*, *P.* (*P.*) *rostrata* var. *trimpleyensis*, *Tesseraspis*, *Poraspis*, and *Anglaspis*.

The highest locality from which *P.* (*S.*) *leathensis* is recorded is about 110 ft. above the main " *Psammosteus* " Limestone (16. Clapgate Cottage Quarry), whilst the lowest occurrence of *P.* (*B.*) *crouchi* is about 170 ft. above the limestone (98. Sudford Dingle 2). Thus, there is a gap of some 60 ft. between the two, and pending further information regarding the range of these species, the *leathensis* Zone is here regarded as extending 140 ft. above the main " *Psammosteus* " Limestone. The provisional determination of *P.* (*S.*) *leathensis* for small pteraspids from Hopton Brook given by Dineley & Gossage (1959 : 232), has now been verified by Dr. White. However, though recorded as occurring 250 ft. above the " *Psammosteus* " Limestone, it is now evident that owing to faulting their position relative to the " *Psammosteus* " Limestone is uncertain.

Zone of *Pteraspis* (*Belgicaspis*) *crouchi* Lankester

The *crouchi* Zone is poorly fossiliferous, including much barren marls and silts. However, its onset is marked by a further important faunal change in that some of the heterostracans which constitute such a significant element in the faunas of the preceding zones persist only into the lowest part of the zone, being replaced by new forms at a slightly higher level. The former include *P.* (*P.*) *rostrata* var. *trimpleyensis* as well as *P.* (*P.*) *rostrata* var. indet., *T. symondsi*, which occurs at the very base, ? *Corvaspis*, and *Poraspis* (though it should be noted that *Poraspis sericea* probably extends well into the *crouchi* Zone in Herefordshire and Monmouthshire). Although *Anglaspis* is largely confined to the preceding zones, its occurrence at Clee

St. Margaret (17) demonstrates its persistence into the upper part of the *crouchi* Zone, and *Tesseraspis* is noteworthy for also extending into the middle of the zone.

New forms which appear in the zone include *Weigeltaspis* and *P.* (*P.*) *rostrata* var. *waynensis*, in the lower part, *Pteraspis* (*Pteraspis*) *dairydinglensis* sp. nov. and *P.* (*B.*) *crouchi* var. *heightingtonensis* in the middle, whilst arctolepids, notably *Kujdanowiaspis anglica*, become more common in the upper part of the zone. *P.* (*P.*) *dairydinglensis* also occurs at the same level in the Cleobury Mortimer area (Dineley & Gossage, 1959 : 232. . . . a new and distinctive species of *Pteraspis* "), and it is now evident that the specimens from beds 600 to 850 ft. above the base of the Ditton Series recorded as *P. rostrata* (Dineley & Gossage, 1959) are indeed *P.* (*P.*) *dairydinglensis*. *Cephalaspis* fragments occur throughout the zone, which includes near its base the distinctive cephalaspid fauna of Whitbatch (Stensiö, 1932), and also acanthodian and thelodont scales. The diagnostic fauna of the *crouchi* Zone may therefore be regarded as consisting of *P.* (*B.*) *crouchi*, *P.* (*P.*) *rostrata*, *P.* (*P.*) *dairydinglensis*, *Tesseraspis*, ? *Weigeltaspis*, and *Kujdanowiaspis*. This is a much restricted fauna compared with that occurring with *P.* (*B.*) *crouchi* in Herefordshire and Monmouthshire (White, 1950*a* : 56).

As defined above, the arbitrary base of the *crouchi* Zone is here regarded as being 140 ft. above the main " *Psammosteus* " Limestone. The highest horizon yielding *P.* (*B.*) *crouchi* in the type area is about 800 ft. above the main " *Psammosteus* " Limestone, although it has been recorded from a level of 900 ft. in the Cleobury Mortimer area (Dineley & Gossage, 1959 : 232). The lowest horizon yielding a fauna of the succeeding *leachi* Zone, in the Clee Hills, also occurs about 900 ft. above the main " *Psammosteus* " Limestone. This discrepancy between the two areas may be accounted for by the increase in thickness of the Ditton Series, south-eastwards from Brown Clee Hill to Cleobury Mortimer. Thus, the upper limit of the *crouchi* Zone is arbitrarily placed at 850 ft. above the main " *Psammosteus* " Limestone, though it may occur at a somewhat lower level in the north-west of the area and higher in the south-east.

Zone of *Pteraspis* (*Cymripteraspis*) *leachi* White

Like *P.* (*P.*) *rostrata* and *P.* (*B.*) *crouchi*, *P.* (*C.*) *leachi* occurs widely in the Anglo-Welsh area and also on the Continent. In the Clee Hills area it is commonly found in association with *Protaspis* (*Europrotaspis*) *crenulata* sp. nov., and a diversified arctolepid fauna consisting largely of new forms, but including *Kujdanowiaspis anglica*. A rich fauna, with several new genera and species, has been obtained from Besom Farm Quarry (8), but, like many of the upper Dittonian localities to the east of Brown Clee, it is not possible to estimate its height above the main " *Psammosteus* " Limestone. Besom Farm Quarry is also notable for having yielded *Benneviaspis salopiensis* sp. nov., the youngest cephalaspid in this area.

As in the lower zones, acanthodian and thelodont scales form the major part of the micro-fauna, the former persisting to the very top of the zone where they were collected by King, with a fragment of an arctolepid, from a pellety sandstone immediately underlying the lower Abdon Limestone at Walton Quarry (114) estimated to be about 1,450 ft. above the main " *Psammosteus* " Limestone. The highest locality in the area yielding *Pteraspis* is The Thrift (106), some 1,300 ft. above the main " *Psammosteus* " Limestone. In all, the assemblage characteristic of the *leachi* Zone comprises *Pteraspis* (*C.*) *leachi*, *Protaspis* (*Europrotaspis*) *crenulata* sp. nov., *Benneviaspis salopiensis* sp. nov., *Kujdanowiaspis anglica*, *K. willsi* sp. nov., *Wheathillaspis wickhamkingi* gen. et. sp. nov., *Prescottaspis dineleyi* gen. et sp. nov., *Overtonaspis billballi* gen. et sp. nov., *Onchus wheathillensis* sp. nov., *Nodonchus bambusifer* gen. et sp. nov., and *Ischnacanthus* (?) *anglicus* sp. nov.

As shown above, the lowest records of *P.* (*C.*) *leachi* are from about 900 ft. above the main " *Psammosteus* " Limestone (Bockleton Brook and Upper Overton Quarry), but the junction of the *leachi* Zone with the underlying *crouchi* Zone is drawn arbitrarily some 500 ft. below. Upwards, the zone is regarded as extending to the base of the Clee Series, though its upper part appears to be poorly fossiliferous.

(*c*) *Invertebrates*

A varied invertebrate fauna is known from the Lower Old Red Sandstone of the Anglo-Welsh area, but only a few localities yielding invertebrates have been recorded in the Clee Hills district. The occurrence of Mollusca is of particular interest, since they may imply the establishment of brackish water conditions. Lamellibranchs are known from the lowest part of the Downtonian, and *Modiolopsis* sp. occurs just above the main " *Psammosteus* " Limestone at Criddon Bridge (19). The highest horizon yielding lamellibranchs in the Clee Hills is that recorded by the Geological Survey (Eyles, 1953 : 26), about 150 ft. above the " *Psammosteus* " Limestone, near Ditton Priors.

An occurrence of especial interest is the first record of *Spirorbis* from the Old Red Sandstone. A number of specimens were found attached to the interior of the dorsal disc of the holotype of *Protaspis* (*Europrotaspis*) *crenulata* (p. 269 Text-fig. 16 ; Pl. 43, fig. 3). Like the *Spirorbis* of the *Spirorbis* limestones which occur in the Upper Carboniferous of the Wyre Forest, they imply the establishment of more saline conditions, though lacustrine rather than marine.

Fragments of eurypterids are scattered throughout the lower part of the succession, though they are usually poorly preserved. However, densely packed bands of eurypterid debris incorporating better preserved specimens occur in a green, silty clay at Leath Bank. Crustacean tracks were recorded by Roberts (1863) from a fine sandstone at Bouldon, and further tracks have recently been found there and at Tugford.

(d) *Plants*

Plant remains occur throughout the Downton-Ditton succession, especially the latter, and are usually associated with green, grey or buff shales, siltstones and marly cornstones, and frequently with traces of (?) malachite. A similar association of plant remains with copper minerals was noted by Dixon (1921 : 30, 31) in Pembrokeshire, and he suggested that the precipitation of the malachite may have been effected by the decomposing organic matter, as in the German Kupferschiefer.

The preservation of the plant fragments is almost invariably poor, with the exception of *Pachytheca* which is preserved in both calcareous and carbonized states, and occurs widely throughout the succession. Among the better preserved material, it has been possible to determine *Prototaxites*, *Nematothallus*, ? *Cooksonia*, and *Pachytheca*.

III. UPPER OLD RED SANDSTONE

STRATIGRAPHY

(a) *Farlow Sandstone Series*

The name " Farlow Sandstones " was first applied by King (1925 : 383, 386) to beds outcropping at Farlow and to the south of Titterstone Clee Hill, which contained a typical Upper Old Red Sandstone fauna. However, as has been shown above, the beds outcropping at Clee Burf and ascribed to the Farlow Sandstones (p. 386) are actually Clee Series. King had subsequently arrived at a similar conclusion (*in lit.*), including the beds within his stage III or " Brownstones ". In a later paper King (1934) introduced the term " Farlovian " using it with both a stratigraphical and a time connotation. As Croft (1953 : 430) has pointed out, King subsequently extended it to embrace all Upper Old Red Sandstone beds of the Anglo-Welsh area which unconformably overlie lower horizons. Here, however, it is proposed to retain " Farlovian " purely as a time division and to re-introduce the stratigraphical name " Farlow Sandstones " for the beds of Farlovian age at Farlow and the neighbouring areas.

The total area of outcrop of the Farlow Sandstone Series is very small, the greater part forming the prominent ridge extending east-north-eastwards from Farlow. The remainder consists of small areas outcropping to the south and east of Titterstone Clee Hill.

It has been found convenient to subdivide the Farlow Sandstone Series on the basis of marked lithological contrast into an upper Grey Farlow Sandstone Formation and a lower Yellow Farlow Sandstone Formation.

(i) *Yellow Farlow Sandstone Formation*

As the name implies, the Yellow Farlow Sandstone Formation consists almost entirely of yellow, yellow-buff and sometimes yellow-orange friable sandstones, siltstones and grits. These are largely composed of angular to sub-rounded and sometimes rounded grains of igneous and metamorphic quartz, metamorphic quartzite and quartz-schist, " felsite ", cherts in variety, with rarer grains of muscovite, fresh plagioclase feldspars, tourmaline and garnet (see also Fleet, 1925 : 507). The grain size ranges widely, from silt (0·01 mm.) to grit (3·0 mm.) but averages between 0·02 and 0·8 mm. The grains are poorly cemented, largely by ferruginous and clay cements. Iron staining and thin limonitic banding also occur.

The sandstones tend to be massive and characteristically current-bedded, individual lenses frequently showing rapid alternation of fine and gritty layers which vary widely in degree of sorting. Some of the coarser lenticles are very poorly sorted and it is in these that the most rounded grains commonly occur. The finer sandstones and siltstones are frequently flaggy, with micaceous bedding planes. A few layers of yellow-buff silty marl, rarely exceeding 2 in. in thickness, occur as partings between the sandstone. In contrast, pellets of buff and grey silty marl are commonly incorporated in the sandstones throughout the formation, and also pebbles, largely of vein quartz and to a lesser extent grey and purple quartzites and cherts, especially jasper. The pebbles are mostly sub-angular to angular though a few are rounded, being between 1 and 4 cm. in size. Some of the more conglomeratic lenses also incorporate angular and subangular fragments of sandstone, obviously derived from beds but lately consolidated. The basal 10 ft. of the formation is markedly conglomeratic and contains pebbles up to 14 cm. in size.

The Yellow Farlow Sandstone Formation (which for brevity will hereafter be referred to as the Yellow Formation) is relatively well exposed at Farlow, where its scarp face forms the steep feature of Farlow Bank. An excavation made on the lower slopes of the feature showed the basal conglomerate of the formation to be resting on red-brown silty marls of the Ditton Series. The detailed nature of the contact was obscured by the highly weathered condition of the marls, but there appeared to be little, if any, angular unconformity. The thickness of the Yellow Formation at Farlow is estimated to be about 190 ft., and the dip here, as in the formation along the whole of the Farlow-Walton ridge, averages 20 degrees to the south-south-east.

Eastwards from Farlow, the ridge becomes less steep and exposures are few and poor as far as Oreton, two-thirds of a mile from Farlow, where the Yellow Formation is exposed in a road section along the northern foot of the feature. Although it has not been possible to determine the full thickness of the formation at this point, it appears to be in excess of 110 ft. Still further to the east the feature is much reduced, being breached by the River Rea at Prescott. Here, however, the Yellow Formation again gives rise to a strong feature forming a small river-cliff on the east bank of the Rea, and is well exposed along the road cutting. The thickness of the formation at this point is about 210 ft.

West of Farlow exposures are again few and poor, and the Cornbrook Sandstone oversteps the Carboniferous Limestone and Grey Farlow Sandstone Formation on to the Yellow Formation. However, the Farlow Sandstones again outcrop at Cleeton, 2¼ miles to the south-west.

(ii) *Grey Farlow Sandstone Formation*

The top of the Yellow Formation appears to have been marked by a sudden change in the conditions of deposition, since there is a sharp transition from yellow sandstone and grits to a succession of sandstones, cornstones, rubbly limestone and marls, predominantly grey in colour. The Grey Farlow Sandstone Formation is poorly exposed and such outcrops as occur are mostly of the more resistant sandstones and rubbly limestones. Though the sandstones are largely grey or shades of grey in colour, green, brown, buff and purple bands also occur. Like those of the underlying Yellow Formation they consist predominantly of sub-angular to sub-rounded quartz grains, with grains of quartzite, feldspars and cherts. Similarly, the grain size ranges between silt and grit, but most of the sandstones are fine to medium (i.e. 0·1 to 0·5 mm.).

Many of the sandstones are calcareous, often showing lustre-mottling, and they commonly incorporate small sub-angular and rounded pebbles of vein quartz, cherts, jasper, quartzite and pellets of grey and buff marl. Unlike the homogeneous and relatively massive appearance of the Yellow Formation, the Grey Formation is a far less uniform and more thinly bedded series, individual beds rarely exceeding 4 ft. in thickness. Current bedding is common and many of the finer sandstones are laminated, showing ripple marking and occasionally micaceous bedding planes.

Frequent conglomeratic cornstones occur and are usually grey or green in colour. They are composed largely of fragments of silty and calcareous marl, silty sandstones, and small pebbles like those in the sandstones, set in a matrix of sandy calcareous marl. As in the cornstones of the Lower Old Red Sandstone, fragments of fish are sometimes incorporated.

Also characteristic of the Grey Formation are the lenticular "rubbly" limestone bands, ranging in thickness from a few inches up to 4 ft., which are grey, purple-grey and green-grey in colour. They are composed of fragments of sandy and marly limestone and calcareous sandstone set in a limestone matrix. Sub-rounded, rounded and sub-angular sand grains are commonly incorporated, with occasional pebbles of vein quartz, quartzite and cherts. In thin section, many of the limestones are seen to have a clotted or breccioid structure, having undergone a varying degree of recrystallization, with large zones or centres of finely-crystalline calcite set in a coarsely crystalline matrix. Like the conglomeratic facies of the Abdon Limestones it seems probable that the limestone originated from the breaking up of sheets and crusts of muddy and sandy limestones, with pene-contemporaneous re-cementation by muddy limestones. In several instances secondary precipitation has occurred around many of the fragments. The rubbly limestones are frequently associated with white lustre-mottled sandstones, a further parallel with the Abdon Limestones.

Though the marl pellets which form such a conspicuous element in the composition of the cornstones and many of the sandstones are mainly grey and shades of grey in colour, most of the marls seen to outcrop are red with subordinate green bands. A well-marked red marl, some 6 ft. thick, outcrops immediately above the Yellow Formation, forming the basal member of the Grey Formation. However, owing to the lack of exposures it has not proved possible to assess the total proportion of marls present in the latter.

To the south of Prescott the Grey Formation is estimated to be 275 to 300 ft. thick and is overlain by the basal conglomerate of the Carboniferous Limestone. At Oreton the thickness is reduced to 100 ft., and at Farlow only 40 ft. is present. The significance of this great thinning of the Grey Formation is reflected in the topography and will be discussed below. At Prescott, the Farlow Sandstone Series gives rise to two well-marked escarpments, one formed by the Yellow Formation and the other by the upper part of the Grey Formation, capped by the basal conglomerate of the Carboniferous. Owing to the thinning of the Grey Formation these merge to form a single feature at Oreton, which continues westwards to Farlow.

FAUNA

Though poorly fossiliferous, the Farlow Sandstone Series has long been known to contain a characteristic Upper Old Red Sandstone fish fauna (Egerton, 1862 : 103–105 ; Traquair, 1894–1906 : 128, 129). That collected from the Yellow Formation is largely fragmentary, with a few rare complete plates and scales. With the exception of the original finds described by Egerton, all are in the form of moulds, and despite the fact that most are preserved in medium to coarse, and even gritty sandstones, the detail of the ornamentation is mostly good. In some instances the vascular cavities have been preserved as a delicate filigree of limonitic mud. Apart from the classic locality at Farlow, the exact position of which is now unknown, only two new localities in the Yellow Formation have yielded fossils, one at Farlow (29), the other at Prescott (82). The latter has proved to be the more prolific, the fragments being concentrated in a small lens of gritty sandstone, obviously representing a winnowed deposit. But here, as at Farlow, other plates occur scattered randomly in finer sandstones. Forms represented include *Bothriolepis* sp., *B. macrocephala, Holoptychius* sp., *Pseudosauripterus anglicus* gen. nov., *Eusthenopteron farloviensis* sp. nov., and indeterminate crossopterygian and dipnoan remains.

The Grey Formation is even less fossiliferous than the underlying Yellow Formation, having yielded only a small fauna of mostly indeterminable bone fragments, but including *Holoptychius* sp. The fragments come from the stream section at, 710 yds. (112) and 800 yds. (113) south-south-east of Prescott, in grey, calcareous pebbly sandstones and cornstones, and are much abraded.

IV. LOWER CARBONIFEROUS

(a) *Basal Conglomerate*

Though seemingly outside the scope of the present paper, a brief account of the conglomerate which occurs between the base of the Carboniferous Limestone and the top of the Grey Farlow Sandstone Formation forms a necessary corollary to a description of the latter. The conglomerate has been variously regarded as constituting the uppermost part of the Upper Old Red Sandstone ; as forming the basal bed of the Carboniferous ; and as a transitional bed between the two.

The conglomerate is buff-brown and orange in colour and is largely composed of angular and sub-angular quartz grains, ranging in size between 0·1 and 3·0 mm., the coarser grades predominating. It is as a whole friable, being poorly cemented by ferruginous and calcareous cements. Current bedding is characteristic and the lenses of fine-grade material are usually better cemented. The constituent pebbles range upwards from 0·3 to 15 cm. in size and are mostly sub-angular to sub-rounded. By far the greater proportion are of white and pink vein quartz, with numerous pebbles of purple, pink, yellow and grey quartzites, cherts in variety, jasper and " lydite ".

The conglomerate forms a prominent crest along the greater part of the Farlow-Walton ridge, and is exposed at several points. In the road section of Farlow Bank it is some 6 ft. thick, but owing to slipping its relationship with the underlying Grey Farlow Sandstones and the overlying Carboniferous Limestone is not clear. Eastwards from Farlow, the conglomerate begins to increase in thickness, being some 12 ft. thick at " The Rough ", one-third of a mile due east of Farlow Church. Here, the top of the conglomerate becomes progressively more calcareous upwards, passing into thin-bedded, sandy, pebbly limestones containing numerous crinoid ossicles and characteristic Carboniferous Limestone brachiopods, which are succeeded by typical limestone shales. The conglomerate is not well exposed at Oreton but appears to be at least 12 ft. thick.

The greatest development of the conglomerate is at Prescott, where it is some 35 to 40 ft. thick and gives rise to a small but well-marked escarpment. But neither here nor elsewhere is there a reliable exposure of the contact of the base of the conglomerate with Grey Farlow Sandstones. However, since as will be shown below, the conglomerate truncates the Grey Farlow Sandstone Formation, and in view of the passage from it into the Carboniferous Limestone, the conglomerate can be regarded as forming the basal bed of the Carboniferous. The limestone shales into which the conglomerate passes upwards have been assigned by Vaughan (1905 : 252–254) to his *Cleistopora* zone. Thus the conglomerate may well represent the lower part of K.

V. STRUCTURE

(a) *Folding*

The principal tectonic feature of the area is the folding of the strata along Caledonoid axes to form three major, asymmetrical but relatively simple structural units, the Brown Clee and Titterstone Clee Synclines and the interposing Ledwyche Anticline.

Brown Clee Syncline. The north-western margin of the Brown Clee Syncline is delimited by the Church Stretton fault zone. Its broad north-western flank comprises Ordovician strata dipping south-eastwards from the Stretton Hills, succeeded by the Silurian in Apedale, Wenlock Edge and Hopedale, and in Corvedale by the Downton and Ditton Series dipping at 5 to 10 degrees. The south-eastern flank of the syncline is, in contrast, very narrow and the strata are in general more steeply inclined ; whilst its core is formed by the Clee Series of Brown Clee Hill. The axis of the syncline extends east-north-eastwards from Bromfield, to Hopton Cangeford ; there it swings north-eastwards to Warren Cottage, near which it can be accurately determined in a stream section, and thence to Clee Burf, up to which point it plunges steadily to the north-east. Between Clee Burf and Cleobury North Liberty the direction of plunge becomes reversed and the axis extends east-north-eastwards nearer to the topographic axis of the hill, and it is also paralleled by the plane of the Brown Clee Fault. From Cleobury North Liberty the axis reverts to a north-easterly direction, extending through Morville to Linley and plunging to the south-west.

Titterstone Clee Syncline. This has previously been referred to as the " Clee Hill Syncline " (Whitehead & Pocock, 1947 : 120), but to avoid possible confusion it is here specifically related to Titterstone Clee Hill. It is a more complex structure than the Brown Clee Syncline since in the area of Titterstone Clee Hill it incorporates several subsidiary, but well-defined folds. However, only the north-eastern extremity of the syncline occurs in the area being described and here the subsidiary folding is not evident. Like the Brown Clee Syncline, the Titterstone Clee Syncline is asymmetrical, with a broad north-western flank dipping at 10 to 20 degrees to the south-east, increasing towards the Farlow-Walton ridge where dips of up to 65 degrees occur in the Avonian Limestones. It is possible that these latter dips are, at least in part, a consequence of the collapse and slipping of the limestones into the subterranean stream course which drains from Farlow eastwards to the Factory Cottages, along the southern margin of the ridge (Morris & Roberts, 1862 : 96). The few dips which have been obtained from the succeeding Cornbrook Sandstone indicate that they are inclined at a very much shallower angle, averaging 10 degrees. The south-eastern flank of the syncline is narrow and in the present area consists of Ditton Series dipping moderately steeply, averaging 30 to 40 degrees, to the north-west. The axis of the Titterstone Clee Syncline is difficult to determine with accuracy owing to the cover of the Cornbrook Sandstone and the Coal Measures, but in general it diverges slightly from that of the Brown Clee Syncline, extending from Knowbury east-north-eastwards to Catherton Marshes where it swings to the north-east, continues to Bagginswood, and becomes coincident with the Titterstone Clee Fault.

Ledwyche Anticline. This is an asymmetrical structure separating the Brown Clee and Titterstone Clee Synclines, the north-western flank being narrow and more steeply inclined than the broader south-eastern flank. Its axis is broadly parallel to that of the Brown Clee Syncline and extends east-north-eastwards from Middleton to Langley, and then north-north-eastwards to Coldgreen, where it swings round to assume a north-eastwards course to Underton. In the area of Coldgreen there is some evidence that the fold axis is associated with local faulting. The axis of the Ledwyche Anticline plunges steadily to the north-east, though the amount of plunge decreases between Langley and Underton, north of which it appears to die out.

To the south-west the Brown Clee and Titterstone Clee Synclines, with the interposing Ledwyche Anticline, merge into the structural complex of Silurian strata extending between Ludlow and Presteign and delimited on the west by the Church Stretton fault zone. The relatively more complex structure of the Titterstone Clee Syncline is reflected in its south-westward prolongation through Caynham into the more tightly folded area extending from Richard's Castle, through Leinthall Earls to Presteign, accompanied by a well-defined fault-belt. It has also been suggested that the Titterstone Clee Syncline itself forms the south-western prolongation of the Stafford Syncline (Whitehead & Pocock, 1947 : 122). The Ledwyche Anticline expands south-westwards into the broad anticlinal core in Wenlock Shales at Wigmore Rolls, whilst the Brown Clee Syncline noses out in the area of Adforton. However, to the south-west of the Silurian structural complex extending from Ludlow to Kington, the broad fold of the Brown Clee Syncline appears to have a southern counterpart in the Mynydd Eppynt. To the north-east of the present area the folds become much reduced and lost beneath the Coal Measures of the Wyre Forest.

(b) *Faulting*

There is considerable evidence of faulting in the area, but except where such well-defined horizons as the " *Psammosteus* ", Abdon and Avonian Limestones are affected, the extent, direction and downthrow of the faults are difficult to determine. The majority of the faults are orientated broadly NE.–SW., parallel to the main fold axes, with a minor series approximately at right angles to them. In the few instances where the hade and throw can be determined, the faults appear to be normal. The area is affected by two major faults, the Brown Clee Fault and the Titterstone Clee Fault, both associated with the two major fold axes.

Brown Clee Fault. Nowhere has the plane of the Brown Clee Fault been seen to outcrop, but its effects can first be traced near Gibbridge in the Ledwyche Valley, where it has a Caledonoid trend and downthrows the main "*Psammosteus*" Limestone some 150 ft. to the south-east. North of Gibbridge the fault appears to follow a gently sinuous but broadly N.–S. course, faulting out a prominent sandstone/cornstone feature at Bank House, and downthrowing the Abdon Limestones some 200 ft. to the east near Bockleton Court, where the fault begins to swing round again to the north-east. The Coal Measures of Brown Clee Hill are poorly exposed and it is difficult to trace the fault across them, but it upthrows a narrow strip of Coal Measures to the north-west of Clee Burf, and downthrows the south-eastern portion of the Abdon Burf outcrop. At Hillside, the Brown Clee Fault again displaces the Abdon Limestones, though to a lesser degree than at Bockleton Court, namely some 75 ft. to the east. Over the southern part of Brown Clee Hill the course of the fault appears generally to coincide with the axis of the Brown Clee Syncline. The effects of the fault can next be detected in the stream section 400 yds. south-east of Middleton Priors, and again at Moore Dingle, three-quarters of a mile south-west of Aston Eyre, where the "*Psammosteus*" Limestones are downthrown some 150 ft. to the east.

Titterstone Clee Fault. The present area includes only the north-eastern part of the Titterstone Clee Fault, which extends north-eastwards from Hope Bagot on the southern slopes of Titterstone Clee Hill, in which area it displaces the outcrop of the Avonian Limestones between Gorstly Rough and the Novers, and throws Coal Measures against Lower Old Red Sandstone to the south and south-west of Clee Hill. At Catherton Common the Cornbrook Sandstone is thrown against both Downtonian and Dittonian strata, and though it has not proved possible to measure the amount of downthrow, it would appear to be at least 1,000 ft. to the north-west. North-eastwards from Catherton Marshes the line of the fault coincides broadly with the axis of the Titterstone Clee Syncline, and is defined to the east of the River Rea by vertical and disturbed strata in exposures half a mile north of Detton Hall. Here the fault appears to bifurcate, the main branch extending north-north-eastwards between Prescott and Walton, throwing the Farlow Sandstone Series against the Clee Series, and continuing as the Deuxhill Fault (Whitehead & Pocock, 1947 : 131). The subsidiary branch extends at first east-south-eastwards and can be traced in the stream section to the south of Walton where the beds are contorted and disturbed ; it then gradually swings northwards through Bagginswood, where it is possibly joined by the Brock Hall or Billingsley Fault (Whitehead & Pocock, 1947 : 130). From Bagginswood it continues north-north-eastwards to rejoin the main branch south-west of Chorley. It seems probable that the Titterstone Clee Fault links up to the south-west with the fault extending between Caynham Camp and Leinthall Earls.

Faulting exerts considerable influence on the Farlow-Walton Ridge which, as noted by Murchison (1839 : 121), is broken by a series of dip-faults into a number of blocks which are slightly displaced relative to each other. The amount of downthrow appears to be small, not exceeding 100 ft., and is in most instances to the west. It is along the line of one of the faults that the River Rea cuts across the ridge at Prescott. The escarpment of the " *Psammosteus* " Limestones also shows a number of small displacements owing to minor faulting, as do the Abdon Limestones at Abdon Liberty and Nordybank, again the amount of downthrow usually not exceeding 100 ft.

(c) *Unconformities*

The sequence from the Upper Ludlow Series to the top of the Clee Series is perfectly conformable and there is no evidence to support the existence of the unconformity postulated by King (1934 : 529 ; *in lit.* ; see also Wills, 1948 : 29, 30) to occur at the base of his " Brownstones " or " Division III ". It is evident from King's field-maps (deposited in the Department of Geology, University of Birmingham) that on the western side of Brown Clee Hill his " Brownstones " are broadly equivalent to the Clee Series of the present classification. However, to the east of the hill, King includes a large area of what can now be shown to be the Ditton Series within his " Brownstones ". In postulating an intra-Lower Old Red Sandstone unconformity, King was obviously influenced by the alleged unconformity claimed by Miss D. M. Williams (1926 : 219–225) to occur beneath the Brownstones in the Gower area. But this too has been disproved (George, 1939 : 1–5 ; Croft, 1953 : 429), there being an unbroken sequence from Downtonian to Breconian in South Wales as in the Welsh Borderland.

As is proved by their faunas, a large time-gap exists between the Farlow Sandstone Series and the underlying Lower Old Red Sandstone, yet the angular disconformity between them appears to be very slight. At Farlow the Farlow Sandstones rest upon high Ditton Series, but owing to a divergence in strike, the Dittonian striking NE.–SW. and the Farlovian a little south of east, the Farlow Sandstones rest upon successively higher beds eastwards to Prescott. Between Prescott and Walton it is probable that the Farlow Sandstones overstep onto the Clee Series though the junction is buried beneath the Farlovian cover, the latter having been eroded from the upthrown wedge of Clee Series at Walton. King (1925 : 386) states that beds which he regards as being Farlow Sandstones show much greater angular disconformity on the southern Flanks of Titterstone Clee Hill, where they rest across denuded fold axes in Downtonian and Dittonian strata.

A further break occurs at the top of the Farlow Sandstone Series, although these have previously been suggested to have a perfectly conformable relationship with the succeeding Carboniferous Limestone (King, 1925 : 389 ; Dixon, *in* Watts, 1925 : 395). Again, it is difficult to detect any angular disconformity between the two series except at Farlow, where it may be more apparent than real owing to slipping. However, the magnitude of the break is demonstrated by the relationship of the basal Carboniferous Conglomerate to the underlying Grey Farlow Sandstone Formation. South of Prescott the conglomerate rests upon 275 to 300 ft. of the Grey Farlovian ; three-quarters of a mile to the west at Oreton the Grey Farlovian has become reduced to 100 ft., whilst at Farlow a further three-quarters of a mile to the west it is only 40 ft. thick. Owing to lack of exposures it has not proved possible to ascertain whether the basal conglomerate oversteps onto the underlying Yellow Farlovian to the south-west of Farlow, but south of Silvington an attentuated Avonian sequence and the Grey Farlovian (if present) are overstepped by the Cornbrook Sandstone.

The relationship of the Cornbrook Sandstone to the underlying strata between Cleeton and Factory Cottages, and also on the western flanks of Titterstone Clee Hill, has led one of the writers (H. W. B.) to arrive independently at the same conclusions as George (1956 : 308, 309) regarding its unconformable nature. The Cornbrook Sandstone is itself unconformably overlain by Coal Measures which can be correlated with the Kinlet Beds (Ammanian) of the Wyre Forest Coalfield. The latter beds rest upon Ditton Series along the south-eastern margin of the area and in small outliers near Middleton Scriven and Chorley, whilst the Coal Measures of Brown Clee Hill which are of the same age (Whitehead & Pocock, 1947 : 45–47) rest upon Clee Series. As has been pointed out by Whitehead & Pocock (1947 : 44), in each of these areas, as at Titterstone Clee, the base of the Coal Measures is marked by a distinctive white or grey, hard sandstone which may in part be conglomeratic. A further unconformity occurs between the Kinlet Beds and the succeeding Highley Beds (Morganian) which overstep onto the Ditton and Downton Series in the north-east of the area.

(d) *Age of the Movements*

The principal folding movements affecting the area were those of the Caledonian orogeny which uplifted the Lower Old Red Sandstone of the whole of the Anglo-Welsh region. These movements were of post-Breconian, pre-Farlovian date, but since the upper limit of the age of the Breconian is unknown, though it may extend into the Middle Old Red Sandstone (Croft, 1953 : 431), more precise dating with reference to the continental Devonian stages is impossible. Jones (1956 : 334) has shown that much faulting accompanied the Caledonian folding in South Wales, but it has not proved possible to distinguish any undoubted Caledonian faulting in the Clee Hills, though the alignment of the major faults with the folds indicates some degree of interrelationship. This is particularly apparent in the association of the Brown Clee and Titterstone Clee Synclines and Faults, and in the former instance there is some indication that the Coal Measures are less affected by the Brown Clee Fault than the underlying Clee Series. However, even this can only be taken as evidence of pre-Kinlet Beds faulting with subsequent post-Kinlet Beds rejuvenation. Whatever the age of the faulting, since it appears to be normal, it occurred during periods of tension interspersed between phases of major compression.

A characteristic feature of the folds, and also of the Neen Savage Anticline and the Cleobury Mortimer Syncline to the south (Dineley & Gossage, 1959 : 233), is their asymmetry ; the synclines having broad, north-western flanks and narrow, more-steeply dipping, south-eastern flanks, the anticlines showing the reverse. It has not been possible to determine whether this is an original feature of the Caledonian folding movements, but even if this was so the asymmetry was further accentuated by Carboniferous movements (see also Squirrell & Tucker, 1960 : 167–170). This is demonstrated by the Cornbrook Sandstone which in the area of Cleeton on the north-western flank of the Titterstone Clee Syncline dips at about 10 degrees to the south-east, whilst near to Clee Hill, on the southern flank, it dips to the north-west at 60 to 70 degrees. A further feature of the folds is the gradual swing in strike from the Armoricanoid trend of the Cleobury Mortimer Syncline (Squirrell & Tucker, 1960) to the typical Caledonoid direction of the Brown Clee Syncline, the folds seemingly having rotated about Titterstone Clee Hill. Moreover, due north of the hill the axes of the Ledwyche Anticline and the Brown Clee Syncline have been deflected northwards, as has the Brown Clee Fault ; whilst along the same line the dolerite intrusions of both Brown Clee and Titterstone Clee occur. It is probable that all these features, plus the more complex form of the Titterstone Clee Syncline itself, are reflections of the influence of pre-Caledonian structures at depth.

The Caledonian orogeny was succeeded by a period of epeirogenic movements, marked by unconformities between the Farlow Sandstone Series and the Carboniferous Limestone, and between the latter and the Cornbrook Sandstone. A more profound phase of movement involving some degree of folding followed the deposition of the Cornbrook Sandstone which George (1956 : 307–309) has suggested to be most probably of Namurian age, and preceding the " Middle " Coal Measures or Ammanian (= " Yorkian ". Whitehead & Pocock, 1947 : 40). This was succeeded by early Morganian (= " Staffordian ". Whitehead & Pocock, 1947 : 121) movements, regarded by Wills (1956 : 59) as representing the First Malvernian Movements, and evidenced by the marked overstep of the Kinlet Beds (Ammanian) by the Highley Beds (Morganian) onto the Downton and Ditton Series in the north-east of the area. The only direct evidence of post-Morganian movement in the area is provided by the Deuxhill Fault which throws Highley Beds against Lower Old Red Sandstone ; and it has been suggested (Whitehead & Pocock, 1947 : 122) that the Titterstone Clee Syncline, and presumably the Brown Clee Syncline, owe their present elevation to post-Triassic movements. However, as is shown by the configuration of the Coal Measure basins of Brown Clee and Titterstone Clee, post-Caledonian movements continued folding and faulting along pre-existing axes.

VI. CONDITIONS OF DEPOSITION AND PALAEOGEOGRAPHY

It is necessary to consider the history of the Clee Hills area in the broader context of that of the Anglo-Welsh region. The major tectonic units of the Anglo-Welsh region as defined by Wills (1951) comprise the Welsh geosyncline (Jones, 1938) and the Midland kratogenic block, the boundary between the two broadly delimited by the great line of disturbance extending from Pembrokeshire, through Church Stretton, and possibly northwards into the Lake District (Jones, 1927). By the end of Silurian times the rate of subsidence in the geosyncline had begun to slow down, and the presence of layers of phosphatic pebbles or " bone-beds " in the sediments of the marginal zones indicates pauses in subsidence, or even periods of emergence of areas of the Midland block above the shallow shelf sea which covered it (Lawson, 1954, 1955 ; Squirrell & Tucker, 1960).

The base of the Old Red Sandstone is marked by the Ludlow Bone Bed (White, 1950*a* : 63), a remarkable deposit which has been recorded from a number of localities ranging over a wide area of the Welsh Borderland, and also South Wales (Walmsley, 1959) and the Midlands (King & Lewis, 1912 ; Whitehead & Pocock, 1948 ; Ball, 1951). It appears to be a remanié deposit (Whittard, 1952 : 176, 177) resulting from a prolonged pause in subsidence over the whole area, which marks the inception of the main phase of the Caledonian orogeny, and was accompanied by folding in South Wales. Although the actual bone-beds are lenticular, the Ludlow Bone Bed forms a stratigraphical unit which is probably broadly synchronous over the whole of the area (cf. Denison, 1956 : 389). The conditions of deposition of the Ludlow Bone Bed indicate shallow waters with active bottom currents, and alternation of marine and brackish environments (see Wills, 1948 : 25 ; Whittard, 1952 ; Denison, 1956). Other thin, lenticular bone-beds occur in the lower part of the overlying Grey Downton Formation.

In the Ludlow area, the Ludlow Bone Bed is succeeded by the Downton Castle Sandstone which marks the inception of the great delta plain which formed the major palaeogeographic feature of the Lower Old Red Sandstone. The Downton Castle Sandstone comprises thick, current-bedded sandstones interbedded with laminated siltstone and shales. Despite the evidence adduced by Denison (1956 : 390, 391) for the marine origin of the Downton Castle Sandstone, the lithology, fauna and flora of the sandstones are strongly indicative of fresh-water or brackish deltaic conditions ; whilst the siltstones and shales are brackish, with rare marine incursions. Similar conditions obtain in the South Staffordshire area (Ball, 1951), where there is no need to postulate a lateral facies change to account for the presence of *Hemicyclaspis murchisoni*, as suggested by Schmidt (1959 : 28). But in the geosynclinal zone to the west of Ludlow (Stamp, 1919 ; Earp, 1938, 1940 ; Holland, 1959) the equivalent beds are finer grained, and much more brackish in character, with marine bands near the base and they are considerably thicker. Thus it appears that the sandy-delta facies were confined to the north-western area of the Midland block, whilst the very late stages of geosynclinal subsidence were continuing in the Kerry-Knighton areas, where a brackish-water lagoon environment obtained. The sediments would therefore possibly have been derived from areas lying to the north and possibly the east. Thus the Grey Downton Formation thins north-eastwards from Ludlow (p. 182), and in South Staffordshire the sedimentary structures in the equivalent of the Downton Castle Sandstone indicate a north-easterly origin (Ball, 1951 : 232). The presence of thin, highly localized bone-bed lenticles in the lower part of the succession throughout the area, suggests further brief pauses in subsidence.

In the upper part of the Grey Downton Formation the conditions were largely brackish-water lagoonal, with rare marine incursions, though plant fragments occur disseminated throughout the shales. However, the transition from predominantly grey to red sediments which takes place at the top of the Grey Downton Formation, marks a profound change in the geographic and climatic conditions. Some of the views regarding the conditions under which the Old Red Sandstone was deposited have been summarized by Jones (1956 : 336–338) and, as he points out, many of the early opinions favoured an arid climate. However, many of the Downtonian and

Dittonian marls are strikingly similar to the superficial deposits accumulating at present in parts of Africa with a tropical monsoonal climate. Indeed, red and green colours in sediments are no longer regarded as indicating deposition under arid conditions, but rather of intense weathering under hot, humid conditions (Krynine, 1949). Thus, the dominant red coloration of the Downton and Ditton Series, as well as their lithology, implies a profound alteration in the climatic conditions prevailing over the land-mass from which they were derived.

In the Downton Series marls predominate and suggest an ample supply of lateritic clays resulting from tropical weathering, and deposition under quiet conditions. The marls are probably fluviatile, many being highly micaceous, though some of the clay and silt particles may have been wind-borne. The " race " and nodular limestones appear to be penecontemporaneous with the marls, and may have originated like the Kunkar deposits of modern tropical deltas. There is ample evidence of the fluviatile origin of the pellet rocks and of the sandstone bands and lenses, many of which occur in channels cut into the underlying beds. Current ripple-marks are common, and to a lesser extent desiccation-cracks and rain-prints. The pellet beds probably originated from the erosion of sun-baked clay crusts by " flash " floods, with rapid disintegration of the crusts, attrition of the fragments and re-deposition. Brackish and brackish-marine incursions are marked by bands containing *Lingula* and molluscs, whilst a trilobite has been recorded from the lower part of the Red Downton Series at Ledbury (Piper, 1898). In the upper part of the succession sandstones become more common, e.g. the Holdgate Sandstones, as well as cornstones incorporating fragments of fish. The amount of plant debris also increases, whilst bands with invertebrate fossils are rare.

The overall impression is one of a broad delta-plain, similar to the sub-aerial part of the present Colorado delta (Sykes, 1935). This covers an area of some 3,250 square miles, and all but the finest material is deposited by braided and shifting streams, periodically flushed into coalescing flood sheets. Sediment is then rapidly deposited over wide areas, and the mud plains and flats are left dotted with playas and ox-bow lakes. Elsewhere, mud banks and old levées are eroded and current-raked. Reworking of the sediments is common, and deposition takes place not only in stream channels but occasionally over wide continuous areas. Plant debris is accumulated and macerated by the floods, and is often thinly spread over the flats. Though deposition is very near to sea level, sedimentation is active enough to prevent the advance of the sea over the delta, except in rare incursions (cf. Denison, 1956 : 392, 393).

At its maximum during the Downtonian and Dittonian, the delta probably extended over the greater part of South and Central Wales, its western limits being formed by the uprising Caledonian Mountains, and across the Midland kratogenic block at least as far as North London, its southern margin being formed by the great geosyncline extending from Southern Ireland, through the Bristol Channel, into France and Germany (Simpson, 1951 : 60, 61).

Owing to the lack of fossils in the Old Red Sandstone outcrops to the west of the Church Stretton fault zone, it is impossible to correlate them with the sequence in the type area. Moreover, the " *Psammosteus* " Limestones have not been detected west of the Clee Hills area. However, in the Knighton district, Holland (1959 : 472) gives a thickness of approximately 2,000 ft. for his " Red Downtonian ", which consists of red and green " marls " and sandstone bands. He also points out that cornstones, typical of the Dittonian, are absent, implying a correlation wholly with the Red Downton Formation of the Clee Hills. In the Clun Forest area, Earp (1938 : 127) records a thickness of 1,000 ft.+ for his " Red Downtonian Beds ", but again, it is impossible to correlate them with the type sequence. If these western outcrops are of Downtonian age, the thickness of 2,000 ft. in the Knighton area, compared with 1,200 ft. in the Clee Hills, implies that the rate of subsidence and sedimentation continued to be greater in the basin to the west of the Church Stretton fault zone than on the kratogenic block to the east.

The " *Psammosteus* " Limestones, which extend over the greater part of the Anglo-Welsh Old Red Sandstone outcrop from Shropshire to Pembrokeshire, mark a widespread change in the conditions obtaining over the delta, probably effected by slight variations in geography and climate. The limestones probably originated in a series of lagoons with restricted circulation, and though the " *Psammosteus* " Limestones " phase " was of short duration, it appears to have been broadly synchronous over the whole of the area. As has been shown above, the " *Psammosteus* " Limestones have not yet been found west of the Church Stretton fault zone, and there is no information regarding their extent to the east of its present outcrop. However, during a re-examination of the Streatham Common Boring (Whitaker 1889 : 224–229) instigated by Mr. J. D. D. Smith of the Geological Survey,[1] fragments of fish from the core at a depth of about 1,225 ft. were examined by Mr. H. A. Toombs and determined as *Traquairaspis symondsi*, *Tesseraspis tessellata* and (?) *Corvaspis*. These forms indicate a high Downton or low Ditton horizon, but broadly about the level of the " *Psammosteus* " Limestones. The presence at this level of beds of typical Old Red Sandstone facies in South London raises the interesting point of their relationship with the vertebrate-bearing marine strata of " . . . a late Downtonian or post-Downtonian . . . " age (Straw, 1933 : 139), occurring in the Little Missenden Boring, some 30 miles to the north-west.

The " *Psammosteus* " Limestones usher in a change of conditions between the Downton and Ditton Series ; the sediments become coarser and thick cornstone lenses are developed. Fluviatile conditions are well established, with marked lenticularity of the beds, current bedding, ripple-marks, desiccation-cracks and washouts. These changes probably reflect an increase in the tempo of the uplift of the Caledonian mountains with attendant increase in gradient and rainfall. Associated with this, fish and plant remains become more abundant, particularly in the lower part of the Ditton Series. Erosion surfaces are common, some being deeply incised, suggesting intermittent " sheet " or " flash " flooding, with swiftly flowing but heavily laden streams, which were braided and shifting. Sudden floods flushing out the streams of a hilly region and debouching onto the delta would doubtless engulf living fish, as well as dead organisms and plant debris. The cornstones of the Ditton Series, which are the richest source of fossils, are formed by the pene-

[1] The authors are indebted to the Director of the Geological Survey for permission to publish this information.

contemporaneous erosion of layers of muddy limestone and calcareous mud resulting from such floods. The pellets may be well consolidated or plastic, and vary from angular to rounded, the fish remains being incorporated as fragments. The cornstones are markedly lenticular and frequently well sorted. Nodular limestones and " race " similar to those of the Downton Series also occur. The presence of rare bands of lamellibranchs in the lower part of the Series and *Spirorbis* in the upper indicates brief periods of increased salinity, though in the case of the latter implying playa lacustrine, rather than marine conditions. The Ditton Series are not known to outcrop west of the Church Stretton fault zone, but an extrapolation of their thickness from the Clee Hills implies their continuity into Central Wales. However, it is not possible to determine whether sedimentation continued to be greater in the geosynclinal region or on the margin of the kratogenic block.

Towards the end of Lower Dittonian times there appears to have been a slowing down in the uplift of the Caledonian mountains which is reflected in the sediments becoming finer, with silts greatly predominating over sandstones and cornstones. Thereafter, the increasing coarseness of the strata, persisting into the uppermost Clee Series, reflects renewed and accelerated uplift of the mountains culminating in the main phase of the Caledonian orogeny. In the area of the Clee Hills, the end of the Dittonian is marked by the re-establishment of conditions similar to those under which the " *Psammosteus* " Limestones originated, with the formation of the lower of the Abdon Limestones. A further period of normal conditions ensued before the recurrence of the calcareous lagoon environment and the deposition of the upper Abdon Limestone. The appearance and structure of some of the limestones in the Clee Series suggests that they may have been formed in a manner similar to recent surface limestones, or " calcrete " (see Du Toit, 1954 : 445–447).

The coarse sandstones and grits of the Clee Series with predominantly sub-angular pebbles, imply increased gradients and the closer proximity of mountain footslopes. The composition of the sandstones indicates that an area of metamorphic and igneous rocks was being subjected to erosion, though some of the pebbles of quartzite and jasper may have been secondarily derived. The source of the Upper Silurian limestone pebbles in the Clee Series poses a problem. It seems likely that the nearby Silurian outcrops of the Welsh Borderland and West Midlands were blanketed by a thick cover of Downtonian and Dittonian rocks by the beginning of Breconian times. However, the pebbles may have been derived from outcrops which lay to the north-east. The Breconian delta probably extended over the whole of the Anglo-Welsh area, though its eastern limits are unknown. It is not possible to estimate the original thickness of the Clee Series, but it may well have compared with that of the Breconian strata in the Brecon Beacons, namely 2,100 ft.+ (Croft, 1953 : 429).

Between Breconian and Farlovian times the Anglo-Welsh Caledonian orogeny reached its culmination and was succeeded by a period of profound erosion and planation, the whole of the Breconian and the upper part of the Dittonian strata having been removed from the area between Brown Clee Hill and Walton prior to the deposition of the Farlow Sandstones. The Yellow Farlow Sandstones appear to mark the re-establishment of deltaic conditions, with ample evidence of very vigorous stream action. The climate appears to have been relatively arid, but a sudden change in climatic conditions ushered in the deposition of the Grey Farlow Sandstones, with a return to monsoonal conditions similar to those of the Dittonian, and with broadly similar types of sediments. In the Clee Hills area the Farlovian strata appears to be wholly fluviatile with an extremely sparse freshwater fish fauna, and in the Grey Farlow Sandstones a few carbonaceous plant remains. The Farlovian delta extended over a wide area, Farlovian strata outcrop in the Forest of Dean, Bristol and the Mendips, and are well represented in South Wales where in the upper part of the succession they interdigitate with marine Devonian beds. Moreover, Farlovian deposits are known from boreholes in the North and East Midlands, as well as the North London area where they are overlain by marine Devonian. Thus the Midland block persisted as an area of relative stability undergoing subsidence, its southern margin being delimited by approximately the same line as that of the Dittonian, extending from Southern Ireland, through the Bristol Channel and the London area, into France. Its northern extent is equivocal but may have persisted into North England (Wills, 1951 : pls. 3–5).

In the area of the Clee Hills, the Upper Old Red Sandstone was terminated by a period of uplift, erosion and planation prior to the deposition of the basal Carboniferous conglomerate and the advance of the sea.

VII. LIST OF LOCALITIES, FAUNA AND FLORA

In addition to the authors' localities, this list incorporates what may be termed " classic " localities and many fossiliferous horizons discovered by the late W. W. King. Where no faunal list is given, the material requires further preparation.

The national grid reference and 2½ inch new series O.S. sheet number are given for each locality, though in the old series the prefix " SO " is replaced by " 32 ", i.e. SO/68 new series = 32/68 old series. Wherever possible the position of each locality is given relative to the main " *Psammosteus* " Limestone, for which the abbreviation " *P* ". L. is used throughout.

1. Abdon Bridge — SO/58
   1,050 yds. E. 6° S. of Tugford Church (5668/8696).
   Cornstone outcropping in bank of stream.
   Ditton Series, lower group ; *c.* 140 ft. above " *P* ". L.
   Tesseraspis sp.

2. Aston Hill Wood 1 — SO/69
   500 yds. W. 42° S. of Morville Church (6663/9358).
   Loose blocks in field below wood, not *in situ.*
   Stratigraphical position uncertain.
   Pteraspis (*Simopteraspis*) *leathensis* White.

3. Aston Hill Wood 2 — SO/69
   430 yds. S. 28° W. of Morville Church (6679/9355).
   Red cornstone exposed in bank.
   Stratigraphical position uncertain.
   Pteraspis sp.
   Poraspis sp.

4. Bache Mill SO/58
170 yds. W. 39° N. of Bache Chapel (5013/8614).
Ludlow Bone Bed.

5. Batch Brook SO/68
1,530 yds. S. 6° E. of Wheathill Church (6232/8076).
Cornstone outcropping in southern bank of stream, a little distance below new footbridge.
Ditton Series, lower group ; *c.* 800 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* var. *heightingtonensis* White.
Arthrodire.
Thelodont scales.
Acanthodian scales.

6. Baucott, Sandy Lane SO/58
510 yds. N. 31° W. of Broncroft (5430/8710).
Green and red sandstones in old quarry on north side of lane.
Downton Series, Red Downton Formation.
Indet. spine.

7. Beaconhill Brook 1 SO/69
1,200 yds. N. 41° E. of Monkhopton Church (6330/9426).
Purple and green micaceous sandstone in cliff in southern bank of stream, 430 yds. upstream from roadbridge.
Downton Series, Red Downton Formation.

8. Besom Farm Quarry SO/68
475 yds. E. 29° S. of Besom Farm (6076/8094).
Cornstone exposed at top of old quarry, on southern side.
Ditton Series, upper group.
Pteraspis (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
Benneviaspis salopiensis sp. nov.
Kujdanowiaspis anglica (Traquair).
Kujdanowiaspis willsi sp. nov.
Wheathillaspis wickhamkingi gen. et sp. nov.
Ischnacanthus anglicus sp. nov.
Onchus wheathillensis sp. nov.
Onchus besomensis sp. nov.
Nodonchus bambusifer gen. et sp. nov.
Acanthodian tooth (*Plectrodus*-type).
Thelodont scales.
Acanthodian scales.
Spirorbis sp.
Pachytheca sp.

9. BITTERLEY WORKS RAILWAY CUTTING SO/57
590 yds. S. 34° E. of Bitterley Church (5740/7685).
Red sandstone in southern face of cutting, about 20 yds. from east end.
Ditton Series, lower group ; immediately overlying " *P* ". L.
Anglaspis sp.

10. BLUCKS HOUSE SO/68
150 yds. SW. of Blucks House (6794/8957).
Sandy cornstone exposed in stream.
Ditton Series, lower group.
Pteraspis sp.
Cephalaspis cf. *langi* Stensiö.
Cephalaspis cf. *fletti* Stensiö.
Cephalaspis cf. *agassizi* Lankester.

11. BOCKLETON BROOK SO/58
1,030 yds. S. 13° E. of Stoke St. Milborough Church (5686/8136).
Cornstone exposed in stream, 30 yds. NE. of roadbridge.
Ditton Series, upper group ; *c.* 900 ft. above " *P* ". L.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.

12. BOULDON, CLEE BROOK SO/58
300 yds. S. 33° E. of Bouldon Church (5484/8500).
Cornstone exposed in Clee Brook.
Downton Series, Red Downton Formation.

13. BOULDON FORD SO/58
420 yds. E. 25° S. of Bouldon Church (5496/8499).
Sandstone and cornstone exposed in stream.
Ditton Series, lower group ; *c.* 50 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* var. *trimpleyensis* White.
Cephalaspis bouldonensis sp. nov.

14. BROCKTON SO/59
160 yds. N. 34° E. from crossroads at Brockton (5789/9389).
On east side of road, in bank north of gate leading into farmyard, and in farmyard.
Ludlow Bone Bed.

15. BROMDON DINGLE BROOK SO/58
400 yds. S. of Cleedownton (5813/8041).
Green sandy shale parting in sandstone-cornstone bluff, 30 yds. downstream from footbridge.
Ditton Series, lower group.
Pteraspis sp.
Poraspis sp.
Thelodont scales.
Acanthodian scales.
Pachytheca sp.

16. CLAPGATE COTTAGE QUARRY SO/58
1,030 yds. E. 35° N. of Tugford Church (5650/8756).
Cornstone in old quarry, 40 yds. from road.
Ditton Series, lower group ; *c.* 110 ft. above " *P* ". L.
Pteraspis cf. (*Simopteraspis*) *leathensis* White.
Traquairaspis symondsi (Lankester).
Anglaspis sp.
Tesseraspis sp.
? Cephalaspid.
Acanthodian scales, spines and jaws.
Thelodont scales.

17. CLEE ST. MARGARET SO/58
630 yds. N. 38° W. of Clee St. Margaret Church (5609/8480).
Green sandstone and cornstone in eastern bank of stream section.
Ditton Series, lower group ; *c.* 675 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* var. *heightingtonensis* White.
Anglaspis sp.
Cephalaspid.
Arctolepid.

18. COLD WESTON QUARRY SO/58
490 yds. W. 8° N. of Cold Weston Church (5474/8309).
Old quarry.
Ditton Series, lower group ; *c.* 850 ft. above " *P* ". L.
? Arctolepid.

19. CRIDDON BRIDGE SO/69
1,620 yds. E. 36° S. of Upton Cresset Church (6681/9159).
Red silty sandstone outcropping in stream.
Ditton Series, lower group ; 5 ft. above " *P* ". L.
cf. *Kujdanowiaspis* sp.
Modiolopsis sp.

20. DAIRY DINGLE SO/68
1,425 yds. E. 3° S. of Neenton Church (6503/8767).
Cornstone exposed in stream.
Ditton Series, lower group ; *c.* 800 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *dairydinglensis* sp. nov.
Acanthodian scales.
Thelodont scales.
Cephalaspid.
Indet. spine.
Pachytheca sp.

21. DERRINGTON REA BRIDGE SO/69
500 yds. SE. of Derrington (6099/9052).
Cornstone exposed in stream section, 20 yds. downstream from bridge.
Ditton Series, lower group ; *c.* 500 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *dairydinglensis* sp. nov.
Thelodont scales.
Acanthodian scales.
Cephalaspid.

22. DEVIL'S MOUTHPIECE QUARRY SO/58
1,850 yds. E. 43° N. of Upper Hayton Church (5303/8210).
Sandstone and cornstone in old quarry.
Ditton Series, lower group ; *c.* 400 ft. above " *P* ". L.

23. DODSHILL BANK SO/58
630 yds. S. 23° W. of the Three Horseshoes Inn (5978/8138).
Grey and buff silty sandstone in small quarry.
Ditton Series, ? upper group.
Prototaxites sp.
Pachytheca sp.
Nematothallus sp.
cf. *Cooksonia* sp.

24. DOWN QUARRY, THE SO/68
350 yds. S. 10° E. of The Down (6374/8157).
Cornstone exposed in old quarry, largely overgrown.
Ditton Series, upper group.
Pteraspis ? (*Cymripteraspis*) sp.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.

25. EARNSTREY BROOK (LEATH 3) SO/58
570 yds. N. 11° E. of Earnstrey Hall (5752/8889).
Massive cornstone forming waterfall, and grey marl immediately underlying it (see also Wills, 1935 : 427 ; White, 1946 : 210).
Downton Series, Red Downton Formation ; *c.* 70 ft. below " *P* ". L.
Traquairaspis symondsi (Lankester).
Anglaspis macculloughi A. S. Woodward.
Corvaspis kingi A. S. Woodward.
Tesseraspis tessellata Wills.
Cephalaspis sp.
Onchus sp.
Pachytheca sp.

26. EARNSTREY HALL 1 SO/58
510 yds, E. 7° N. of Earnstrey Hall (5787/8825).
Red sandstone exposed in stream, 70 yds. downstream from road.
Ditton Series, lower group ; *c.* 400 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.

27. EARNSTREY HALL 2 SO/58
600 yds. E. 6° S. of Earnstrey Hall (5794/8826).
Sandstone exposed immediately below bridge.
Ditton Series, lower group ; *c.* 420 ft. above " *P* ". L.
Pteraspis cf. (*Belgicaspis*) *crouchi* Lankester.

28. FARLOW BROOK BRIDGE SO/68
325 yds. N. 32° W. of Farlow Church (6380/8088).
Cornstone exposed in bank on south side of lane.
Ditton Series, upper group.
Pteraspis ? (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
Arctolepid.
" Ichthyodorulite."

29. FARLOW, OLD LANE SO/68
160 yds. E. 35° N. of Farlow Church (6408/8071).
Sandstones exposed on south side of cutting, about half-way down old lane.
Yellow Farlow Sandstone Series.
Crossopterygian indet.

30. FOX COVERT SO/68
720 yds. E. 20° N. of Wheathill Church (6283/8237).
Cornstone poorly exposed in stream.
Ditton Series, upper group.

31. FOXHOLE COPPICE, MONKHOPTON SO/69
910 yds. E. 25° S. of Monkhopton Church (6180/9308).
Cornstone forming waterfall.
Downton Series, Red Downton Formation ; 25 ft. below " *P* ". L.
Kallostrakon sp.
Acanthodian scales, jaws and spines.

32. FOXHOLE COPPICE, NEWTON DINGLE SO/58
1,650 yds. W. 9° S. of the Three Horseshoes Inn (5849/8168).
Red and green cornstone and sandstone exposed in cliff above east bank of stream.
Ditton Series, lower group ; *c.* 750 ft. above " *P* ". L.

33. GREAT NORTHWOOD SO/68
60 yds. ESE. of Great Northwood (6798/8410).
Old quarry.
Ditton Series, upper part of lower group.
Pteraspis cf. (*Belgicaspis*) *crouchi* Lankester.

34. HEATH QUARRY SO/58

230 yds. W. 15° N. of Heath Church (5551/8570).
Cornstone exposed at western end of old water-filled quarry.
Ditton Series, lower group ; *c.* 300 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.
? *Weigeltaspis* or *Tesseraspis* sp.

35. HILLS, THE SO/57

? 1,230 yds. E. 20° S. of Downton Hall (5386/7895) ; a classic locality, the exact position of which is uncertain.
Old quarry.
Ditton Series, lower group.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.
Cephalaspis sp.
Acanthodian.

36. HOPTONGATE SO/58

2,040 yds. W. 2° N. of Hopton Cangeford Church (5299/8047).
Old quarry.
Ditton Series, lower group ; *c.* ? 700 ft. above " *P* ". L.
Pteraspis sp.
Kujdanowiaspis anglica (Traquair).

37. HUDWICK DINGLE 1 SO/69

980 yds. S. 39° E. of Monkhopton Church (6314/9274).
Thick cornstone immediately overlying the " *P* ". L. at the confluence of Hudwick and Stapeley Dingles.
Ditton Series, lower group ; immediately overlying " *P* ". L.
Pteraspis ? (*Simopteraspis*) *leathensis* White.
Traquairaspis symondsi (Lankester).
Anglaspis sp.
Tesseraspis sp.
Corvaspis kingi A. S. Woodward.
Ischnacanthus wickhami sp. nov.
Acanthodian scales (cf. *Gomphodus* sp. and *Nostolepis* sp.) and spine.
Thelodont scales.
Cephalaspid.
Pachytheca sp.

38. HUDWICK DINGLE 2 SO/69

1,700 yds. S. 28° E. of Monkhopton Church (6330/9206).
Pavement of cornstone exposed a few yards below confluence of streams.
Ditton Series, lower group ; *c.* 250 ft. above " *P* ". L.
Pteraspis sp.

39. HUDWICK DINGLE 3 SO/69
1,310 yds. S. 34° E. of Monkhopton Church (6323/9243).
Purple and green cornstone and sandstone in west bank of stream.
Ditton Series, lower group; *c.* 80 ft. above "*P*". L.
Pteraspis (*Simopteraspis*) *leathensis* White.

40. HUDWICK DINGLE 4 SO/69
1,510 yds. S. 32° E. of Monkhopton Church (6329/9224).
Grey-green cornstone outcropping 10 ft. above base of thick cornstone-sandstone series, forming rapids and waterfall.
Ditton Series, lower group; *c.* 175 ft. above "*P*". L.
Pteraspis (*Pteraspis*) *rostrata* (Agassiz) var. indet.
Cephalaspid.
Thelodont scales.
Acanthodian.
Pachytheca sp.

41. HUDWICK DINGLE 5 SO/69
2,190 yds. S. 29° E. of Monkhopton Church (6353/9168).
Red and green cornstone exposed in stream, 175 yds. upstream from footbridge.
Ditton Series, lower group; *c.* 400 ft. above "*P*". L.
Pteraspis sp.
Acanthodian scales.
Pachytheca sp.

42. JUBILEE BROOK 1 SO/57
500 yds. W. 35° N. of Upper Ledwyche (5503/7948).
Green sandstone exposed in stream.
Ditton Series, lower group; *c.* 250 ft. above "*P*". L.
Pteraspis (*Pteraspis*) *rostrata* var. *waynensis* White.
Poraspis sp.
? *Corvaspis* sp.
Acanthodian spine.

43. JUBILEE BROOK 2 SO/57
460 yds. W. 22° N. of Upper Ledwyche (5501/7938).
Stream section.
Ditton Series, lower group.

44. KIDNALL GUTTER 1 SO/58
870 yds. S. 15° W. of Tugford Church (5551/8628).
Red cornstone exposed in stream.
Ditton Series, lower group; 15 ft. above "*P*". L.
Pteraspis (*Pteraspis*) *rostrata* (Agassiz) var. indet.
Cephalaspid.
Thelodont scales.
Acanthodian scales.

45. KIDNALL GUTTER 1A
875 yds. S. 13° W. of Tugford Church (5554/8627).
Cornstone exposed in stream.
Ditton Series, lower group ; *c.* 30 ft. above " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.
? *Traquairaspis* sp.
Acanthodian spines.

46. KIDNALL GUTTER 2 SO/58
880 yds. S. 12° W. of Tugford Church (5556/8626).
Cornstone exposed in stream.
Ditton Series, lower group ; *c.* 75 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* cf. var. *trimpleyensis* White.

47. KIDNALL GUTTER 3 SO/58
890 yds. S. 4° W. of Tugford Church (5567/8625).
Cornstone exposed in stream.
Ditton Series, lower group ; *c.* 180 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.
Pteraspis ? sp. nov.
Cephalaspid.
Thelodont scales.
Acanthodian scales and spines.

48. KIDNALL GUTTER 4 SO/58
900 yds. S. 2° W. of Tugford Church (5570/8625).
Grey, brown and red mottled sandstone with cornstone lenses, exposed in stream section.
Ditton Series, lower group ; *c.* 200 ft. above " *P* ". L.
Pteraspis sp.
? *Tesseraspis* sp.
Thelodont scales.
Acanthodian scales.
Pachytheca sp.

49. LEATH 1 SO/58
30 yds. E. of Leath Cottage (5846/8989).
Deep gulley running parallel with road, on north side of Leath Bank (see also White 1950*a* : 70, 71).
? Ditton Series, lower group.
Pteraspis (*Simopteraspis*) *leathensis* White.
Cephalaspid.
Pachytheca sp.

50. LEDWYCHE BROOK SO/58

1,480 yds. E. 9° S. of Hopton Cangeford Church (5620/8018).
Cornstone exposed in west bank of stream, 180 yds. downstream from ford.
Ditton Series, lower group ; *c.* 60 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* var. *trimpleyensis* White.
Cephalaspid.
Acanthodian scales and spine.
Thelodont scales.

51. LITTLE OXENBOLD SO/59

540 yds. SE. of Little Oxenbold (5906/9117).
Purple and green cornstone and marls exposed in stream section.
Downton Series, Red Downton Formation ; 50 ft. below " *P* ". L.
Traquairaspis symondsi (Lankester).
Anglaspis sp.
Corvaspis sp.
Tesseraspis sp.
Acanthodian.

52. LOWE FARM QUARRY SO/68

150 yds. S. 19° W. of Lowe Farm (6310/8034).
Cornstone exposed in small overgrown quarry.
Ditton Series, ? upper group.
Pteraspis sp.
? Arctolepid.

53. LOWER INGARDINE FORD SO/68

780 yds. S. 35° E. of Wheathill Church (6250/8150).
Very coarse cornstone exposed in stream.
Ditton Series, upper group.
Pteraspis (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
cf. *Kujdanowiaspis anglica* (Traquair).
Arctolepid.
Cephalaspid.
Thelodont scales.

54. LYDEHOLE SO/58

1,150 yds. N. 38° E. of Upper Hayton Church (5244/8179).
Grey-buff cornstone exposed in stream section.
Ditton Series, lower group ; *c.* 130 ft. above " *P* ". L.
Pteraspis sp.

55. LYE BROOK 1 SO/69
1,050 yds. S. 19° E. of Morville Church (6728/9298).
Cornstone exposed in stream, forming waterfall.
Downton Series, Red Downton Formation ; 125 ft. below " *P* ". L.
Traquairaspis symondsi (Lankester).
Cephalaspid.
Acanthodian spines.

56. LYE BROOK 2 SO/69
1,140 yds. S. 11° E. of Morville Church (6717/9287).
Block of green cornstone in stream, uncertain whether *in situ*.
Stratigraphical position uncertain, but the locality is below " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.
Acanthodian spine.

57. LYE BROOK 3 SO/69
1,100 yds. S. 15° E. of Morville Church (6723/9290).
Cornstone outcropping about 1½ ft. above waterfall formed by mudstone and fine calcareous sandstones.
Downton Series, Red Downton Formation ; *c.* 90 ft. below " *P* ". L.
Traquairaspis symondsi (Lankester).
Thelodont scales.
Acanthodian scales.
Cephalaspid scales.

58. LYE BROOK 4 SO/69
1,180 yds. S. 4° E. of Morville Church (6703/9281).
Cornstone outcropping in stream, forming waterfall.
Ditton Series, lower group ; 75 ft. above " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.
Poraspis sp.

59. MIDDLETON PRIORS SO/69
210 yds. N. 9° W. of Middleton Priors School (6235/9049).
Cornstone exposed in stream section, 20 yds. above bridge.
Ditton Series, lower group ; *c.* 500 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.
Acanthodian scales.
Thelodont scales.

60. MILL FARM BRIDGE SO/68
210 yds. E. 30° S. of Mill Farm (6408/8127).
Cornstone exposed in cutting on east side of road.
Ditton Series, upper group.
Pteraspis ? (*Cymripteraspis*) *leachi* White.
Thelodont scales.

61. MUNSLOW SO/58
820 yds. E. 12° N. of Munslow Church (5286/8787).
Ludlow Bone Bed.

62. NETCHWOOD COMMON SO/69
2,260 yds. S. 13° W. of Monkhopton Church (6202/9110).
Cornstone exposed in stream section.
Ditton Series, lower group ; *c.* 400 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.

63. NEW BUILDINGS A SO/58
510 yds. S. 38° E. of New Buildings (5796/9898).
Grey-green cornstone exposed at top of gully.
Ditton Series, lower group.

64. NEW BUILDINGS B SO/58
500 yds. E. 22° S. of New Buildings (5808/8918).
Large blocks of grey-green cornstone in field.
Ditton Series, lower group ; blocks not *in situ.*
Pteraspis cf. (*Belgicaspis*) *crouchi* Lankester.

65. NEW BUILDINGS C SO/58
475 yds. E. of New Buildings (5810/8934).
Grey cornstone outcropping half-way up escarpment.
Ditton Series, lower group.

66. NEW BUILDINGS D SO/58
290 yds. S. 37° E. of New Buildings (5781/8914).
Red sandstone exposed in stream near foot of escarpment.
Downton Series, Red Downton Formation ; 110 ft. below " *P* ". L.
Indet. spine.

67. NEW BUILDINGS E/2 SO/58
590 yds. S. 17° E. of New Buildings (5782/8882).
Red and green sandstone and cornstone exposed at top of stream section.
Ditton Series, lower group ; *c.* 110 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* (Agassiz).

68. NEW BUILDINGS E/3 SO/58
320 yds. S. 34° E. of New Buildings (5784/8912).
Cornstone exposed in stream section.
Downton Series, Red Downton Formation ; *c.* 75 ft. below " *P* ". L.
Traquairaspis symondsi (Lankester).
Anglaspis sp.
Acanthodian spines.

69. New Buildings E/3A SO/58
430 yds. S. 35° E. of New Buildings (5789/8904).
Cornstone exposed in stream section.
Ditton Series, lower group ; 2 ft. above " *P* ". L.
Pteraspis sp.

70. New Buildings F SO/58
570 yds. E. 27° S. of New Buildings (5817/8910).
Green sandy cornstone exposed in stream section.
Ditton Series, lower group ; *c.* 175 ft. above " *P* ". L.

71. New Inn 1 SO/58
1,440 yds. W. 43° S. of Upper Hayton Church (5092/8012).
Cornstone forming waterfall in stream, 640 yds. above road.
Downton Series, Red Downton Formation ; 16 ft. below " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.
Traquairaspis symondsi (Lankester).
Poraspis sp.
Tesseraspis sp.
Cephalaspid.
Acanthodian spines and teeth.
Thelodont scales.
Pachytheca sp.

72. New Inn 2 SO/58
1,260 yds. S. 44° W. of Upper Hayton Church (5099/8012).
Cornstone forming waterfall in stream, 700 yds. above road.
Ditton Series, lower group ; *c.* 75 ft. above " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.
Poraspis sp.
Anglaspis sp.
Acanthodian scales, spines and teeth.
Thelodont scales.
Pachytheca sp.

73. Newton Dingle 1 SO/58
520 yds. W. 40° N. of the Three Horseshoes Inn (5963/8221).
Cornstone exposed in eastern bank of stream.
Ditton Series, upper group ; *c.* 900 ft. above " *P* ". L.
Pteraspis (*Cymripteraspis*) sp.
Kujdanowiaspis anglica (Traquair).

74. NEWTON DINGLE 2 SO/58
700 yds. N. 9° W. of the Three Horseshoes Inn (5990/8254).
Cornstone exposed in stream section immediately below lane.
Ditton Series, upper group ; *c.* 950 ft. above " *P* ". L.
Pteraspis ? (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
Arctolepid.
Acanthodian scales and spine.
Thelodont scales.

75. OAK DINGLE SO/58
920 yds. E. 4° N. of Tugford Church (5656/8712).
Red sandstone exposed in stream, 100 yds. upstream from road.
Ditton Series, lower group ; *c.* 125 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* var. *trimpleyensis* White.
Traquairaspis symondsi (Lankester.)
Tesseraspis sp.
Cephalaspis sp.
Acanthodian spine.
Thelodont scale.

76. OLDFIELD, THE LOBBY SO/68
140 yds. S. of The Lobby (6710/8850).
Green sandy cornstone exposed in stream.
Ditton Series, lower group.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.

77. OLD FORGE QUARRY SO/58
330 yds. S. 35° E. of Bouldon Church (5488/8489).
Sandstones and cornstones in old quarry.
Ditton Series, lower group.

78. PARK BARN QUARRY SO/58
850 yds. E. 29° N. of Tugford Church (5639/8744).
Red cornstone exposed in old quarry, 70 yds. from road.
Ditton Series, lower group ; *c.* 80 ft. above " *P* ". L.
Pteraspis sp.
Tesseraspis sp.
Cephalaspid scales.
Thelodont scales.
Acanthodian scales and spines.

79. PARK DINGLE SO/69
2,460 yds. S. 35° E. of Monkhopton Church (6386/9158).
Green sandstone and shales with pellet bands, exposed in stream section and forming waterfall.
Ditton Series, lower group.

80. PARLOUR COPPICE SO/69
660 yds. W. 7° N. of Upton Cresset Church (6500/9253).
Cornstone exposed in stream section.
Ditton Series, lower group ; *c.* 400 ft. above " *P* ". L.
Tesseraspis sp.

81. POSTON OLD QUARRY SO/58
1,300 yds. N. 17° W. of Hopton Cangeford Church (5452/8154).
Cornstone and sandstone in old quarry.
Ditton Series, lower group ; *c.* 800 ft. above " *P* ". L.
Pteraspis sp.
Arctolepids.

82. PRESCOTT CORNER SO/68
110 yds. N. of Prescott Farm (6636/8118).
Sandstones exposed in south side of bank at sharp bend in road, 5 ft. above road surface.
Yellow Farlow Sandstone Series.
Bothriolepis sp.
Holoptychius sp.
Pseudosauripterus anglicus (A. S. Woodward).
? *Eusthenopteron farloviensis* sp. nov.
Indet. Crossopterygii.

83. PRESCOTT, OLD LANE SO/68
175 yds. S. 15° W. of Prescott Farm (6632/8092).
Pellety sandstones exposed below hedge on east side of lane.
Grey Farlow Sandstone Series.

84. PRESCOTT, REASIDE SO/68
300 yds. N. 35° W. of Prescott Farm (6622/8129).
Cornstone exposed in east bank of river.
Ditton Series, upper group ; ? *c.* 1,100 ft. above " *P* ". L.
Pteraspis (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
Kujdanowiaspis cf. *anglica* (Traquair).
Prescottaspis dineleyi gen. et sp. nov.
Thelodont scales.
Pachytheca sp.

85. REA BRIDGE, DITTON PRIORS SO/68
1,650 yds. E. 28° N. of Ditton Priors Church (6216/8985).
Loose blocks of cornstone in field.
Ditton Series, lower group ; not *in situ.*
Pteraspis (*Pteraspis*) *rostrata* (Agassiz) var. indet.

86. Rea Brook, New House Farm SO/68
160 yds. W. of New House Farm (6375/8810).
Cornstone exposed in banks of stream.
Ditton Series, lower group ; ? *c.* 650 ft. above " *P* ". L.
Kujdanowiaspis anglica (Traquair).

87. Shipton SO/59
160 yds. E. 42° S. of Shipton Church (5630/9176).
Exposure in sides of lane.
Ludlow Bone Bed.

88. Shortwood SO/57
1,300 yds. W. 30° S. of Downton Hall (5179/7870).
Old quarry.
Ditton Series, lower group.

89. Silvington Church SO/67
Cornstone exposed on west side of road near to churchyard gate (6215/7984).
Ditton Series.

90. Silvington, Drainage Gully SO/68
550 yds. N. 30° W. of Cleeton Court (6094/8002).
Cornstone exposed in drainage gully.
Ditton Series, lower group ; ? *c.* 575 ft. above " *P* ". L.
Pteraspis cf. (*Belgicaspis*) *crouchi* Lankester.

91. Silvington, Old Quarry 1 SO/68
175 yds. N. 6° E. of Silvington Church (6216/8002).
Cornstone exposed in old quarry.
Ditton Series.
Pteraspis sp.

92. Silvington, Old Quarry 2 SO/68
270 yds. NE. of Silvington Church (6231/8003).
Cornstone exposed in old quarry.
Ditton Series.
cf. *Climatius* sp.

93. Silvington, Upper Quarry SO/68
1,630 yds. S. 20° E. of Wheathill Church (6272/8076).
Massive cornstone, 14 ft.+ thick, exposed in old quarry.
Ditton Series, upper group.
Pteraspis ? (*Cymripteraspis*) *leachi* White.

94. SILVINGTON, WATERFALL SO/67
1,250 yds. W. 5° N. of Silvington Church (6096/7994).
Cornstone exposed in north bank of stream, 5 yds. upstream from waterfall.
Ditton Series, lower group ; ? *c.* 600 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* var. *heightingtonensis* White.
? *Tesseraspis* sp.
Kujdanowiaspis anglica (Traquair).
Arctolepid.
Cephalaspid.
Acanthodian.

95. STAPELEY DINGLE SO/69
990 yds. SE. of Monkhopton Church (6320/9279).
Red and green cornstone immediately overlying " *P* ". L. and forming first waterfall above the confluence with Hudwick Dingle.
Ditton Series, lower group ; immediately overlying " *P* ". L.

96. STOTTESDON BROOK SO/68
1,150 yds. S. of Stottesdon Church (6724/8184).
Cornstone exposed in stream.
Ditton Series, upper group ; ? *c.* 1,100 ft. above " *P* ". L.
Pteraspis ? (*Cymripteraspis*) *leachi* White.
Protaspis ? (*Europrotaspis*) *crenulata* sp. nov.
? *Kujdanowiaspis* sp.
Thelodont scale.

97. SUDFORD DINGLE 1 SO/69
780 yds. S. 9° E. of Monkhopton Church (6268/9273).
Grey-green sandy cornstone exposed in stream.
Ditton Series, lower group ; 3–4 ft. above " *P* ". L.
Traquairaspis symondsi (Lankester).

98. SUDFORD DINGLE 2 SO/69
1,250 yds. S. 11° W. of Monkhopton Church (6235/9230).
Pavement of cornstone at confluence of streams.
Ditton Series, lower group ; *c.* 170 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.

99. TARGROVE DINGLE 1 SO/57
910 yds. E. 25° N. of Whitbatch (5251/7789).
Red cornstone exposed in stream section, 140 yds. below drive to Downton Hall.
Ditton Series, lower group ; 18 ft. above " *P* ". L.
Anglaspis sp.

100. TARGROVE DINGLE 2 SO/57

930 yds. E. 30° N. of Whitbatch (5249/7795).
Red and green cornstone and sandstone exposed in stream, 40 yds. below drive to Downton Hall.
Ditton Series, lower group.
Pteraspis sp.

101. TARGROVE DINGLE 3 SO/57

900 yds. E. 36° N. of Whitbach (5243/7803).
Red and green cornstone forming waterfall near top of western tributary, 60 yds. above drive to Downton Hall.
Ditton Series, lower group ; *c.* 250 ft. above " *P* ". L.
Pteraspis (*Belgicaspis*) *crouchi* Lankester.

102. TARGROVE DINGLE 4 SO/57

920 yds. E. 23° N. of Whitbatch (5253/7787).
Cornstone forming waterfall, 160 yds. below drive to Downton Hall.
Downton Series, Red Downton Formation ; 6 ft. below " *P* ". L.

103. TARGROVE DINGLE 5 SO/57

920 yds. E. 28° N. of Whitbatch (5250/7793).
Cornstone forming waterfall, 78 yds. below drive to Downton Hall.
Ditton Series, lower group.

104. TARGROVE DINGLE 6 SO/57

1,030 yds. E. 13° N. of Whitbatch (5266/7775).
Red calcareous mudstone outcropping in stream section 330 yds. below drive.
Downton Series, Red Downton Formation ; *c.* 100 ft. below " *P* ". L.
Kallostrakon sp.
" *Onychodus*."
Acanthodian.
Anaspid.

105. TARGROVE QUARRY SO/57

1,000 yds. E. 31° N. of Whitbatch (5254/7799).
Old quarry on north side of drive to Downton Hall.
Ditton Series, lower group ; *c.* 175 ft. above " *P* ". L.
Pteraspis (*Pteraspis*) *rostrata* var. *trimpleyensis* White.
Traquairaspis symondsi (Lankester).
Acanthodian scales.
Thelodont scales.

106. Thrift, The SO/58
900 yds. S.27° E. of Clee St. Margaret Church (5682/8363).
Cornstone exposed in west bank of road, 200 yds. south of Burnt House.
Ditton Series, upper group ; *c.* 1,300 ft. above " *P* ". L.
Pteraspis ? (*Cymripteraspis*) *leachi* White.

107. Upper Ledwyche, Old Quarry SO/57
600 yds. W. 11° N. of Upper Ledwyche (5488/7933).
Cornstone outcropping in old quarry.
Ditton Series, lower group ; ? *c*, 200 ft. above " *P* ". L.
Pteraspis sp.

108. Upper Overton Quarry SO/68
100 yds. N. 30° W. of Upper Overton (6647/8688).
Cornstones in quarry, now overgrown and in cutting on south side of quarry.
Ditton Series, upper group ; ? *c.* 900 ft. above " *P* ". L.
Pteraspis ? (*Cymripteraspis*) *leachi* White.
Protaspis (*Europrotaspis*) *crenulata* sp. nov.
Overtonaspis billballi gen. et sp. nov.
? *Kujdanowiaspis* sp.
? *Wheathillaspis* sp.
Cephalaspid.
Thelodont scales.
Acanthodian scales.

109. Upton Cresset Quarry SO/69
150 yds. N. of Upton Cresset Church (6560/9259).
Purple cornstone exposed in old quarry.
Ditton Series, lower group ; *c.* 400 ft. above " *P* ". L.
Pteraspis cf. (*Pteraspis*) *dairydinglensis* sp. nov.
Cephalaspid scales and fragments.
Acanthodian scales and spine.
Thelodont scales.

110. Upton Lodge Quarry SO/69
1,360 yds. S. 12° E. of Upton Cresset Church (6586/9124).
Cornstone exposed in old quarry.
Ditton Series, lower group.
Indet. spine.

111. Wallsbatch Quarry SO/68
1,300 yds. E. 35° N. of Faintree Hall (6720/8965).
Cornstone exposed in old quarry.
Ditton Series, lower group.

112. WALTON BROOK 1 SO/68
710 yds. S. 31° E. of Prescott Farm (6670/8051).
Sandy cornstone exposed in stream.
Grey Farlow Sandstone Series.
Holoptychius sp.

113. WALTON BROOK 2 SO/68
800 yds. S. 37° E. of Prescott Farm (6680/8048).
Grey calcareous sandy pebbly cornstone exposed in stream.
Grey Farlow Sandstone Series.

114. WALTON QUARRY SO/68
175 yds. N. 15° W. of Walton (6757/8138).
Pellety sandstone at foot of quarry face.
Ditton Series, upper group; immediately beneath lower Abdon Limestone; *c.* 1,450 ft. above "*P*". L.
Arctolepid.
Acanthodian scale.

115. WHITBATCH LANE SO/57
200 yds. E. 12° N. of Whitbatch (5193/7759).
Exposure in roadside at sharp angle in lane.
Downton Series, Red Downton Formation.
Cephalaspis sp.

116. WHITBATCH QUARRY SO/57
300 yds. NE. of Whitbatch (5195/7776).
The fauna listed probably comes from more than one locality, but mainly from old quarry.
Ditton Series, lower group; *c.* 200 ft. above "*P*". L.
Pteraspis (*Pteraspis*) *rostrata* (Agassiz).
Cephalaspis fletti Stensiö.
Cephalaspis whitbatchensis Stensiö.
Cephalaspis whitei Stensiö.
Cephalaspis lankesteri Stensiö.
Cephalaspis acutirostris Stensiö.
Cephalaspis ? sp. nov.

117. WILDERNESS SO/58
500 yds. E. 35° S. of Ashfield (5911/8917).
Cornstone exposed in stream, 40 yds. south of roadbridge.
Ditton Series, lower group; *c.* 500 ft. above "*P*". L.

118. Winterburn Bridge SO/68
950 yds. NW. of Upper Overton (6592/8740).
Cornstone exposed below bridge.
Ditton Series, ? top of lower group.
Pteraspis sp.
Cephalaspid.
Acanthodian scales.
Thelodont scales.

119. Witchcot-Poston Dingles SO/58
1,120 yds. N. 39° W. of Hopton Cangeford Church (5421/8124).
Sandstone and cornstone exposed in scar on east bank, near confluence of Witchcot and Poston Dingles.
Ditton Series, lower group ; *c.* 800 ft. above " *P* ". L.
Pteraspis sp.

120. Woodhouse Quarry SO/57
? 1,400 yds. W. 16° N. of Downton Hall (5157/7967).
Cornstones exposed in old quarry.
Ditton Series, lower group.

121. Yewtree Dingle SO/69
1,200 yds. W. 22° S. of Morville Church (6596/9348).
Green calcareous sandstone and cornstone, exposed amongst roots of tree at head of dingle.
Ditton Series, lower group ; *c.* 50 ft. above " *P* ". L.
Pteraspis (*Simopteraspis*) *leathensis* White.

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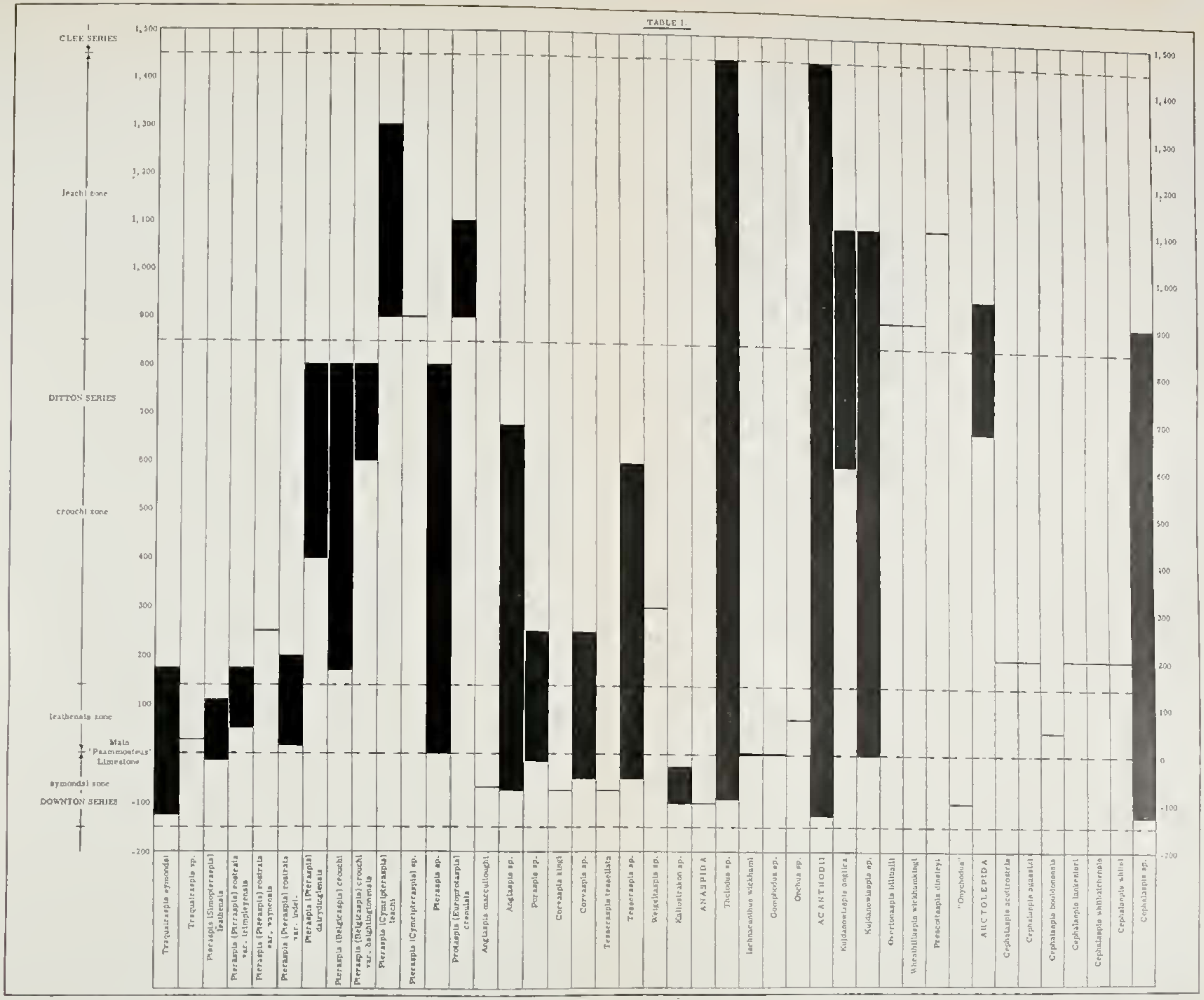
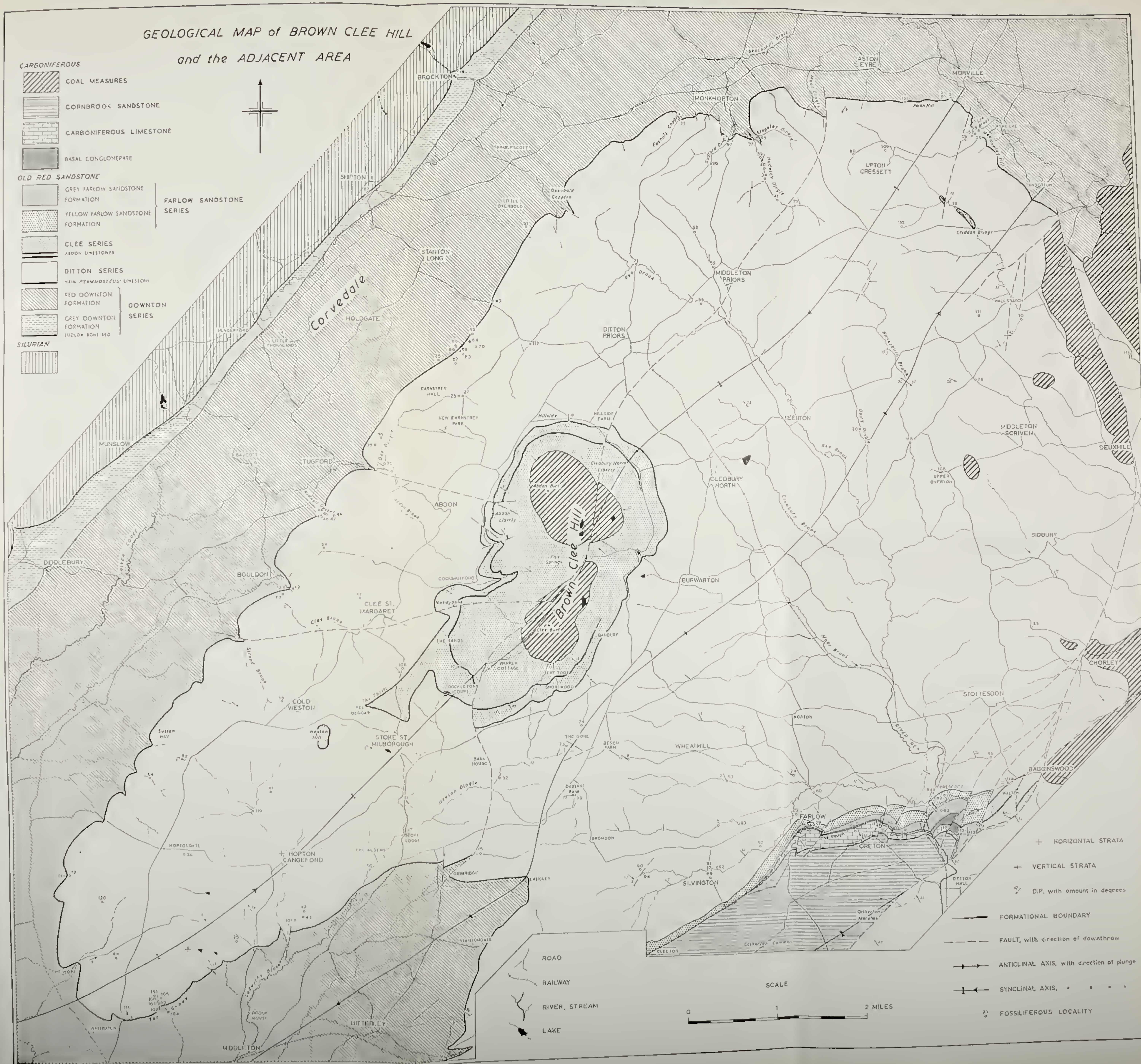


TABLE 1. Range chart of uppermost Downtonian and Dittonian vertebrate faunas in the area of Brown Clee Hill. The ranges given in the Table are compiled only from localities whose position relative to the main " *Psammosteus* " Limestone can be calculated. Thus they do not represent the absolute ranges of the forms listed.


GEOLOGICAL MAP of BROWN CLEE HILL
and the ADJACENT AREA
CARBONIFEROUS
COAL MEASURES
CORNBROOK SANDSTONE
CARBONIFEROUS LIMESTONE
BASAL CONGLOMERATE
OLD RED SANDSTONE
GREY FARLOW SANDSTONE FORMATION
YELLOW FARLOW SANDSTONE FORMATION
FARLOW SANDSTONE SERIES
CLEE SERIES
ABDON LIMESTONES
DITTON SERIES
MAIN PSAMMOSTEUS LIMESTONES
RED DOWNTON FORMATION
GREY DOWNTON FORMATION
LUDLOW BONE BED
DOWNTON SERIES
SILURIAN
Corvedale
Brown Clee Hill
BROCKTON
SHIPTON
STANTON LONG
HOLDGATE
MUNSLOW
DIDDLEBURY
TUGFORD
ABDON
BOULDON
CLEE ST. MARGARET
COLD WESTON
STOKE ST. MILBOROUGH
HOPTON CANGEFORD
BITTERLEY
MIDDLETON
MONKHOPTON
ASTON EYRE
MORVILLE
UPTON CRESSETT
MIDDLETON PRIORS
DITTON PRIORS
NEENTON
CLEOBURY NORTH
BURWARTON
MIDDLETON SCRIVEN
DEUXHILL
SIDBURY
CHORLEY
STOTTESDON
WHEATHILL
SILVINGTON
FARLOW
ORETON
BAGGINSWOOD
PRESCOTT
CLEE HILL
HORIZONTAL STRATA
VERTICAL STRATA
DIP, with amount in degrees
FORMATIONAL BOUNDARY
FAULT, with direction of downthrow
ANTICLINAL AXIS, with direction of plunge
SYNCLINAL AXIS
FOSSILIFEROUS LOCALITY
ROAD
RAILWAY
RIVER, STREAM
LAKE
SCALE
0
1
2 MILES